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Policies for sustainable land management in the East African highlands

Summary of papers and proceedings of a conference held at the United Nations Economic Commission for Africa (UNECA), Addis Ababa, Ethiopia 24–26 April 2002

Socio-economics and Policy Research

International Food Policy Research Institute

International Livestock Research Institute

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Socio-economics and Policy Research Working Paper 50

editors
S. Benin, J. Pender and S. Ehui

International Food Policy Research Institute
2033 K Street, NW, Washington, DC 20006, USA

International Livestock Research Institute
P.O. Box 30709, Nairobi, Kenya

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Editors' affiliations

Samuel Benin, International Livestock Research Institute (ILRI), P.O. Box 5689, Addis Ababa, Ethiopia
John Pender, International Food Policy Research Institute (IFPRI), 2033 K Street, NW, Washington, DC 20006, USA
Simeon Ehui, ILRI, P.O. Box 5689, Addis Ababa, Ethiopia

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Foreword

This is the proceedings of an international conference on 'Policies for sustainable land management in the East African highlands' held at the United Nations Economic Commission for Africa, Addis Ababa, Ethiopia, 24–26 April 2002. The conference was convened to bring together researchers, policy makers, development practitioners, donors and other stakeholders to review, discuss and synthesise the findings and policy implications of the research on sustainable land management in the East African highlands. The conference also aimed at: increasing the awareness of policy makers and other stakeholders on the impact of policies, programmes and other factors on land management, agricultural productivity, poverty and food security; discussing promising strategies to promote more sustainable land management, increased agricultural productivity and reduced poverty and food insecurity; and considering priorities for policy action and future research.

The conference was attended by more than 110 participants including the Honourable Belay Ejigu, Vice Minister of Agriculture, Ethiopia; the Honourable Dr W. Kisamba-Mugerwa, Minister of Agriculture, Uganda; and the Honourable Madame Grace Akello, Minister of Gender, Labour and Social Development (Entandikwa), Uganda.

This summary proceedings includes full texts of welcoming and opening addresses, the background and objectives of the research and the conference, summaries of 25 papers presented at the conference, discussants' comments and a synthesis of the findings of the papers and discussions. The programme details and the list of participants are also attached.

For the past four years, the International Food Policy Research Institute (IFPRI) and the International Livestock Research Institute (ILRI) have been involved in a collaborative research project on 'Policies for sustainable land management in mixed crop–livestock systems in the highlands of East Africa'. This research was undertaken with financial support from the governments of Switzerland, Germany, Norway, the United States, the United Kingdom, The Netherlands, Italy and Japan and members of the Consultative Group on International Agriculture Research (CGIAR).

Many organisations and their representatives from the region and outside have also been collaborating partners in the research. These include: Mekelle University, the Ethiopian Agricultural Research Organization, Ethiopian regional bureaus of agriculture and planning, Makerere University, the National Agricultural Research Organization of Uganda, the Agricultural Policy Secretariat of Uganda, the Agricultural University of Norway, the Centre for Development Research of the University of Bonn, Wageningen University and Research Centre, Purdue University and the University of Manchester.

The conference was cosponsored by IFPRI, ILRI, the United Nations Economic Commission for Africa (UNECA), the International Centre for Research in Agroforestry (ICRAF), the East and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), the African Highlands Initiative (AHI), the Soil, Water and Nutrient Management (SWNM) Programme of the CGIAR and the Regional Land Management Unit (RELMA) of the Swedish International Development Cooperation Agency (SIDA).

Many staff from ILRI and IFPRI were involved in organizing the conference and managed its logistical details.

On behalf of ILRI and IFPRI, we would like to express our gratefulness to all the donors and partners for their support in the research. We are also grateful to all the cosponsors of the conference and all the other individuals who worked tirelessly to make the conference a success.

Our particular appreciation goes to the many officials, community leaders and farmers who graciously and patiently participated in the research and responded to our numerous questions.

John Pender
International Food Policy Research Institute

Simeon Ehui
International Livestock Research Institute

Overview of findings, implications and discussions

Overview of findings and implications

J. Pender

International Food Policy Research Institute (IFPRI), USA

Introduction

The research presented at the conference mainly addressed the problem of the downward spiral of land degradation, low and declining agricultural productivity as well as poverty and food insecurity. The proximate causes of land degradation and low productivity in the East African highlands are relatively well established, including increasing cultivation on steep and marginal lands, low and declining use of fallow, loss of vegetative cover resulting from deforestation and overgrazing, limited use of soil fertility-enhancing inputs such as fertilisers, manure and leguminous crops and limited adoption of soil and water conservation practices. Underlying these proximate causes are many socio-economic and policy-related factors, including population pressure, poverty, limited development of and access to markets, infrastructure and credit, limited farmer awareness of appropriate and profitable technologies, limited development or responsiveness of agricultural research and extension systems to farmers needs, land tenure insecurity, land fragmentation and limited development of land markets, limited education of farmers, limited alternative livelihood options and policies related to these factors. The impacts of these underlying factors are generally not well understood. Most of the papers at the conference focused on investigating the impacts of such factors on livelihood strategies and land management, and the effects of these responses on agricultural productivity, household welfare and natural resources.

Many hypotheses regarding the factors affecting livelihoods and land management in the East African highlands and their implications have been put forward and investigated. A key hypothesis underlying much of the research was that the prospects for sustainable land management in any particular location depend upon the 'development pathways' (defined as common patterns of change in livelihood strategies) that may be pursued. These development pathways in turn depend upon factors determining comparative advantages of different locations, including the biophysical factors affecting agricultural potential, access to markets and infrastructure, population density and others (Pender et al. 1999).

Other factors potentially influencing communities' and households' choice of livelihoods and land management practices include households' endowments of natural capital (e.g. land size and quality), human capital (e.g. labour force, education, farming experience, knowledge about farming practices, gender composition of household), physical capital (e.g. livestock and equipment), financial capital (savings and access to credit) and social capital (e.g. participation in organisations, reputation and relationships in the community); policies and programmes involved at the local level (e.g. technical

assistance programmes, credit programmes, food aid and poverty reduction programmes, land redistribution or other land policies); and local institutions affecting natural resource management (e.g. land tenure, local regulations and bylaws on use of communal land or other resources). These factors may affect households' choice of livelihoods (e.g. to produce livestock or participate in non-farm activities vs. crop production) and land use and land management decisions (e.g. the choice of what crops to plant, what inputs to use and in what proportion, whether and how much to invest in irrigation, soil and water conservation measures, tree planting or other investments on the land; whether to use land management practices such as fallow, slash and burn, crop rotation, intercropping, mulching, incorporation of crop residues etc.). All of these choices and decisions may have important impacts on the sustainability and productivity of agriculture, income, food security and welfare.

Findings of the research

As might be expected, the findings of the conference papers with regard to this complex set of factors and interactions are diverse and do not always tell a simple story. This reflects the complexity of factors affecting and affected by livelihood and land management decisions, and the diverse nature of the East African highlands. The countries emphasised in the conference are Ethiopia, Uganda and Kenya. The findings are the following:

Underlying determinants of comparative advantages

Factors influencing agricultural potential (e.g. climate, altitude, topography, soils) have substantial, and, sometimes unexpected, impact on livelihood strategies, land management, productivity and resource outcomes.

Climatic factors strongly influence crop choice (Kruseman et al.)[1] and income sources in Tigray, Ethiopia[2] (Pender et al.), with greater importance of perennials and less importance of small ruminants, perishable annuals and food aid as income sources in higher rainfall areas. The climate in Tigray also strongly influences livestock production and use of land management practices such as purchased inputs, manure, mulch and soil bunds (Kruseman et al.). In both Tigray and Oromiya,[3] household crop income was greater in the lower rainfall areas in 1998 (Pender et al.; Jabbar et al.) probably as a result of more intensive use of inputs in such areas. Use of several inputs and land management

1. Throughout this overview, author references are to papers presented in the workshop.
2. Tigray region lies in northern Ethiopia with international borders with Eritrea and Sudan. It belongs to the African drylands known as Sudano-Sahelian Region. Rainfall in Tigray is limited and highly uncertain, characterised by frequent droughts.
3. Oromiya region, located in the central and southern part of Ethiopia, is the largest region and among the most diverse in the country. Rainfall ranges from 200 mm annually in the eastern part to 2000 mm in the western part. Much of the region has high agricultural potential, with much of Ethiopia's coffee being produced in this region.

practices (labour, oxen power, seeds, fertiliser, manure, intercropping and burning) and crop yields were higher in lower rainfall areas of Tigray in 1998 perhaps as a result of favourable weather that year in areas of usually low rainfall (Pender et al.). By contrast, income and welfare are dramatically reduced during droughts, especially for households lacking access to credit (Holden et al.).

In the highland regions of Ethiopia, total factor productivity is highest in Amhara[4] and lowest in Tigray, probably due in part to differences in climate and other biophysical determinants of agricultural potential (Ehui et al.). Livestock density is higher in lower rainfall areas of Oromiya, while investment in small ruminants is higher in higher rainfall areas of Tigray. Other farm income (e.g. from sales of tree products) are also greater in higher rainfall areas of Tigray (Pender et al.). Perceived erosion problems are lower in higher rainfall areas of Tigray, probably due to greater vegetative cover (Pender et al.), and grazing land quality is perceived to have improved (or declined less) in higher rainfall areas of Amhara (Jabbar et al.). On the other hand, leaching may be higher in high rainfall areas, though this issue was not fully investigated by the studies presented at the conference.

In Kenya, cash crops are more important compared to maize, while cattle densities are higher and woodlots are more common in higher rainfall areas (Place et al. (b)).

In Uganda, there are substantial differences in cropping patterns across different agro-climatic zones, coffee being most common in the higher rainfall Lake Victoria zone and eastern highlands, bananas in the southwest, maize in the eastern highlands, cassava in the medium rainfall zone in central Uganda and millet and sorghum in the lower rainfall zone in the north (Nkonya et al.). Fertilisers are often used for maize production in the eastern highlands, close to the Kenya border, than elsewhere in the country. Use of mulch and crop rotation are abundant while slash and burn are rare in the southwest highlands. This is probably related to the banana and annual cropping systems in this region. Incorporation of crop residues is most common in the unimodal rainfall areas in the north, probably because plowing is most common in the area (Jagger and Pender). Crop yields differ across the agro-climatic zones, with maize, beans and sweet potato yields highest in the eastern highlands, coffee yields highest in the high rainfall Lake Victoria zone and millet yields highest in the lower rainfall areas in the north (Nkonya et al.). Insignificant differences in perceptions of soil erosion problems were found between most zones, although sheet erosion was more commonly perceived as a problem in the southwest highlands.

Altitude also influences livelihoods and land management. Altitude had a strong effect on crop choice and livestock production in Tigray (Kruseman et al.). Small ruminants production seem more important at lower altitudes in Tigray, while non-farm income is greater at higher altitudes (Pender et al.). More local and improved seeds are used at higher elevations in Tigray, while burning and fertiliser use are less common. Crop productivity is lower (i.e. yields are lower, controlling for input use and land management practices) at

4. Amhara region, located in the central and north-western part of Ethiopia, is bordered internationally by The Sudan in the west, and is also quite diverse. Annual rainfall varies from 300 mm in the east to over 2000 mm in the west.

higher elevations in Tigray, though altitude has an insignificant impact on perceptions of land degradation. In Amhara, by contrast, declining availability and quality of grazing land are perceived to be greater problems at higher elevation (Jabbar et al.). In Kenya, cash crops, dairy cattle and woodlots are most common at intermediate altitudes, as are better quality houses (Place et al. (b)). In Uganda, beans are more common at higher elevation, while millet and cassava are less common (Nkonya et al.). Farmers at higher altitudes are more likely to apply manure (Jagger and Pender) and household refuse (Nkonya et al.) to their fields, perhaps because fields are more likely to be near or below residences. Biomass production of *mucuna* (a leguminous cover crop) is lower at higher altitude, and thus using this soil fertility management method may be less effective at higher elevations (Kaizzi et al.). Productivity of several crops, including maize, cassava and sweet potatoes is also lower at higher elevation (Nkonya et al.). Controlling for slope and other factors, erosion is perceived to be less of a problem at higher altitudes in Uganda (Nkonya et al.).

Topography also influences crop choice, land management and land degradation. In Tigray, farmers invest more in stone terraces on slopes (especially near the bottom of the slope), and use more burning, intercropping and reduced tillage but less seeds on slopes (Pender et al.). Not surprisingly, perceived erosion is greater on steeper slopes, but no significant differences in productivity due to slope were found in Tigray. In Uganda, coffee and maize are more likely to be planted on top of a slope than elsewhere, while sorghum is more common in the middle of the slope (Nkonya et al.). Use of slash and burn, fertiliser, mulch, incorporation of crop residues and crop rotation is greater on slopes than flat terrain in Uganda. These findings suggest that the intensity of crop production is greater on sloping lands in Uganda, probably in part due to greater population density in the highlands, but also may be due to better volcanic soils in the highlands of Uganda (Kaizzi et al.; Ssali). As in Tigray, perceived erosion is greater on steeper slopes in Uganda. However, productivity of several crops is higher on moderate slopes (maize, cassava, millet, sweet potatoes), perhaps because of better highland soils and better drainage on such slopes. Hillsides are thus not necessarily marginal lands from the standpoint of agricultural productivity, though they are more subject to erosion problems.

Soil quality and land degradation also influence crop choices, land management and production. In Uganda, coffee and bananas are less common on shallow soils, probably because these are important cash and/or food crops (both in the case of bananas), while sorghum and bananas are less common on soils perceived to be infertile (Nkonya et al.). Areas of eastern Uganda with better soils obtain higher returns to fertiliser and leguminous cover crops than areas with poor soils, even though maize yields without such inputs are much higher in the better soil areas (Kaizzi et al.). Where soils are poor, the returns to these technologies are higher after several years of continuous cropping (Kaizzi et al.). Thus, in areas with poor soils, farmers may wait until soils are depleted before investing in improved land management. Yields of millet, beans and coffee are also lower on poorer (shallower or infertile) soils in Uganda (Nkonya et al.). Erosion problems are perceived to be more severe on medium and shallow soils than deep soils, and on soils considered to be infertile in Uganda (Nkonya et al.). Erosion has unclear effects on yields in Uganda.

In Tigray, farmers invest more in erosion management on soils perceived to be good soils (Kruseman et al.) and less in stone terraces on black soils than other soils (Pender et al.). Farmers use fewer inputs on degraded soils (Kruseman et al.), including less labour and improved seeds (Pender et al.). They use more seeds, reduced tillage and intercropping but less contour plowing on shallow soils (Pender et al.). Crop yields and productivity are lower on black soils, shallow soils and sandy soils than other soils in Tigray. Erosion problems are perceived to be greater on sandy soils, less fertile soils or where gullies are already present in Tigray, while decline in soil fertility is perceived to be greater on less fertile or shallow soils (Pender et al.). Land degradation is also associated with declining human health indicators in Tigray (Kruseman et al.).

These findings support concerns about a declining spiral of land degradation, low productivity and poverty, especially in Tigray. Investment on poorer soils is less, productivity is lower, and land degradation appears to be worsening more on soils that are already degraded. This degradation is associated with indicators of poverty, such as poorer health, as well as with lower agricultural production. The findings suggest that efforts to promote fertiliser use will be more effective if they focus on areas of higher rainfall and better soils, and that alternative soil fertility management approaches are likely to be needed in areas of poorer climate and soils.

Access to markets and roads has substantial positive impacts on livelihood strategies, land management and incomes in Kenya, but more limited and mixed impacts in Ethiopia and Uganda.

The main difference between the Central and Western Kenyan highlands is better access to the large Nairobi market and to infrastructure, technical assistance, credit and other services that are associated with that proximity in the central highlands (Place, Njuki, Murithi and Mugo (Place et al. (a)). Probably as a result of their better access, farmers in the central highlands have successfully adopted higher-value cash crops and improved dairy production, invest more in agriculture and land improvement, achieve higher yields and earn substantially higher incomes than farmers in the Western Kenya highlands (Place et al. (a)). In Central Kenya, there is more dairy production, use of zero grazing, investment in improved cattle breeds and fodder sources, and more manure and fertiliser use, especially on cash crops (Place et al. (a)). More generally, better access to urban markets in Kenya is associated with greater adoption of cash crops (especially in higher rainfall areas), livestock and woodlots, and all of these are associated with better housing quality (as indicated by the roof material) (Place et al. (b)). Farmers in Western Kenya depend more on non-farm income as a result of lower farm income (Place et al. (a)). Land degradation problems are worse in Western Kenya, while farmers in Central Kenya perceive land quality to be improving (Place et al. (a)).

In the Ethiopian highlands, access to district towns and all-weather roads has some impact on livelihoods, but more limited and mixed impacts than access to the Nairobi market in Kenya. Crop income is higher closer to towns in Tigray (Pender et al.), while livestock investment, livestock returns and total income are higher closer to towns in Amhara (Jabbar et al.). Access to all-weather roads is associated with greater reliance on off-farm income sources in both Tigray and Amhara, and also with greater dependence

on higher-value crops in Amhara (Jabbar et al.). In Oromiya, livestock investment and total household expenditures are higher in areas of better access (Jabbar et al.).

Land management practices are also influenced by market and road access in Ethiopia, though with some unexpected results. In Tigray, Pender et al. found more use of oxen and improved seeds closer to towns but, surprisingly, less use of fertiliser and contour plowing. Use of labour, fertiliser, burning and contour plowing is greater closer to all-weather roads in Tigray. In Amhara, use of manure, household refuse, fertiliser and reduced tillage is greater closer to towns, while investments in live fences and incorporation of crop residues are more common and reduced tillage less common closer to access roads (Benin). Crop productivity is higher closer to towns in Tigray but not in Amhara, while road access is associated with lower productivity in Amhara but not in Tigray. There exist insignificant associations of market and road access with perceptions of cropland degradation in Tigray (Pender et al.). Access to towns is associated with less effective collective action in managing community woodlots and grazing lands in Tigray (Berhanu et al.), but has an insignificant impact on perceived changes in grazing land availability or quality in Amhara (Jabbar et al.). In Uganda, greater market access is associated with more income from banana production, more production of beans but less production of millet or sorghum, more use of manure on bananas, more use of fertiliser and improved fallow, more investment in woodlots and less use of slash and burn (Jagger and Pender; Nkonya et al.; Sserunkuuma). Market access is associated with higher productivity of some crops (beans, millet and sweet potatoes) but lower productivity of others (maize and coffee) though the effects of market access on land management practices also indirectly influence yields. Access to roads is associated with more maize but less cassava production, less cattle production, more use of manure, crop rotation and incorporation of crop residues, but less use of improved fallow and higher productivity of some crops (coffee and sweet potatoes). Access to markets and roads has insignificant connection with perceived erosion in Uganda (Nkonya et al.).

Access to irrigation increases the intensity of crop production but does not directly affect productivity or land degradation in Ethiopia.

In both Tigray and Amhara, irrigation is associated with greater use of labour, oxen power, improved seeds, fertiliser and manure, as a result of multiple cropping (Pender et al.; Benin). In both these regions, irrigation has an insignificant direct impact on crop productivity (controlling for input use and land management practices), but it contributes to higher yields by increasing farming intensity. Similarly, irrigation has insignificant direct impacts on perceptions of land degradation in these regions, but indirectly affects land degradation by affecting the intensity of land management.

Population pressure and small farm sizes generally contribute to agricultural intensification, as argued by Boserup and her followers. Population pressure also affects livelihood strategies to some extent, favouring crop over livestock production at high population densities, but has mixed or limited impact on income and land degradation, depending on the context.

In Tigray, higher population density is associated with greater use of inputs in crop production, including labour, oxen power, fertiliser and manure (Kruseman et al.; Pender et al.). Intercropping and contour plowing are also more common in more densely

populated areas, while smaller farms are more prone to use fertiliser, contour plowing and intercropping and less likely to use reduced tillage (Pender et al.). Despite these effects, population pressure and farm size have insignificant impacts on crop yields, incomes and perceived land degradation indicators in Tigray (Pender et al.). The impacts on yields and incomes are limited, probably due to the minimal and sometimes offsetting effects of different responses to population pressure. Moderate population pressure contributes to the effectiveness of community management of woodlots and grazing lands in Tigray, while high population contributes to breakdown of collective action (Berhanu et al.).

In Amhara, population pressure was associated with some aspects of intensification, including greater use of improved seeds, crop rotation and incorporation of crop residues, but also (surprisingly) with more use of reduced tillage and less use of contour plowing, draft animal power and manure (Benin). The negative effects of population pressure on plowing and manure use is counter productive, probably due to the negative impact of human population pressure on cattle ownership as a result of declining grazing land availability and quality (Jabbar et al.). Thus, population pressure does not necessarily result in intensification of all inputs, since it may reduce the ability of farmers to afford some inputs, such as oxen. Consistent with this, higher population density is also associated with less dependence on cattle production as a source of income in Tigray (Pender et al.) and Oromiya (Jabbar et al.), and with lower livestock numbers per household in Oromiya, though it is associated with higher livestock density per hectare of land (Jabbar et al.).

Population pressure contributes to expanded crop production and income in Oromiya, but is associated with lower crop yields (Benin) and income in Amhara (Jabbar et al.). This suggests that population pressure contributes to land degradation and declining yields to a greater extent in Amhara. This concern is supported by bio-economic model results from one area of Amhara, showing that population growth and land degradation are together causing significant declines in food production and income per capita, increasing the problem of food deficits (Holden et al.).

In Kenya, higher population density is associated with expanded crop production and higher livestock density, though at a diminishing rate (Place et al. (b)). Population pressure does not significantly affect the mix of crop production between food and cash crops in Kenya (Place et al. (b)) or Tigray (Kruseman et al.). It is also associated with more investment in woodlots in Kenya (Place et al. (b)), and more other farm income (e.g. from tree products) in Tigray (Pender et al.). On the other hand, small farmers in Western Kenya have fewer trees on their farms than larger farms (Swallow and Wangila).

In Uganda, population pressure and smaller farm sizes are associated with greater use of fertiliser, manure, pesticides and incorporation of crop residues (Nkonya et al.; Sserunkuuma). On the other hand, high population density impedes adoption of improved fallow, since land scarcity is costly for farmers to fallow for even one season (Delve and Ramisch). Population pressure is associated with lower yield in some crops but higher yield in others in Uganda, and has insignificant impacts on perceived erosion (Nkonya et al.). However, smaller farms have lower yields of several crops in Uganda (beans, millet and coffee) and suffer from greater erosion problems, suggesting that

population pressure is indirectly having negative impacts on sustainability and welfare by leading to smaller farm sizes.

Impacts of policies, programmes and institutions

Lack of farmer awareness of improved land management technologies is a key constraint to adoption in many places; hence extension and other technical assistance programmes have had important impacts. These impacts are, however, more limited where programmes have promoted technologies that are not well suited to the bio-physical and socio-economic environment.

In Western Kenya, access to information on land management technologies strongly determines adoption of these technologies than many other factors commonly considered important, such as gender of the household head, household wealth, farm size, or participation in local organisations (Swallow and Wangila). Information sources within and outside the village are both associated with greater fertiliser use, while they have different impacts on adoption of soil and water conservation measures (internal sources increased adoption while external sources reduced adoption) (Swallow and Wangila).

Agricultural extension or training programmes have a positive impact on adoption of several land management technologies in Uganda, including use of fertiliser, manure, mulch and reduced burning (Jagger and Pender; Nkonya et al.; Sserunkuuma). The extension system is also associated with increased farm income and reduced erosion in Uganda (Nkonya et al.). However, most farmers in Uganda do not have access to technical assistance programmes, which are not well represented in many remote areas (Jagger and Pender; Nkonya et al.).

The extension system is more widely developed in Ethiopia than in Uganda, and has had a significant positive impact on the adoption of many technologies in the Amhara region, including use of fertiliser, improved seeds, manure, contour plowing and investments in stone terraces and drainage ditches (Benin). As a result, the extension system is contributing to increased yields and crop income in Amhara (Jabbar et al.; Nkonya et al.). In Tigray, by contrast, the extension programme contributes to increased input use (Kruseman et al.), although it has less measurable impact on productivity and incomes, probably because the technologies promoted (especially fertiliser and improved seed) are less suited to the drier climate of this region (Pender et al.).

Technical assistance programmes may also benefit farmers by promoting activities other than crop production and land management. The extent to which programmes have done this and their effectiveness varies greatly, however.

In Ethiopia, the extension programmes had little impact on livestock investment or returns, suggesting lack of focus on livestock as on crop production (Jabbar et al.; Pender et al.). This is despite the fact that returns to investment in several types of livestock were found to be substantial in Tigray and Oromiya (Jabbar et al.; Pender et al.). The government extension programme has also promoted establishment of community woodlots in Tigray, but this appears to be undermining local collective action in managing these

resources, in part because of the tendency of the Regional Bureau of Agriculture to dictate management and harvesting decisions (Berhanu et al.).

In Uganda, by contrast, technical assistance programmes (often run by non-governmental organisations, NGOs) have contributed to higher returns to livestock as well as higher non-farm income, by promoting income diversification. As a result, such programmes have had substantial positive impacts on household incomes. Clearly, the approach to technical assistance (i.e. top–down or demand-driven) is quite important in determining its impacts on farmers' livelihoods.

Credit availability has had mixed impacts on livelihoods and land management. Generally, where credit was used to enable investment in higher value activities and profitable technologies, it has contributed to improved outcomes. By contrast, in instances where it has promoted less profitable activities and technologies, outcomes have not been so favourable.

In Kenya, a key difference between the central and western highlands has been access to formal credit from coffee and tea co-operatives in the former, which has enabled the creation of much more investment and higher incomes in that region (Place et al. (a)). Access to agricultural credit has also contributed to increased use of purchased inputs in the Amhara Region of Ethiopia and in Uganda, and also contributed to higher crop productivity (Benin; Nkonya et al.). Although lack of access to rural credit is hypothesised to be a major constraint to increased fertiliser use in Uganda, little of the available credit is used for fertiliser purchase (Akello). This may be due in part to the scarcity of rural credit in Uganda (Akello), though low profitability of fertiliser in many parts of Uganda is also a factor (Kaizzi et al.; Woelcke et al.). In Tigray, where credit is mainly linked to fertiliser use promoted by the extension programme, credit had insignificant effects on incomes (consistent with the finding noted above on the limited impact of extension on incomes in Tigray), but it is also associated with increasing land degradation (Pender et al.).

In many cases, such as in Tigray (Ethiopia) and Uganda, credit also has insignificant impacts on livestock production and incomes, since credit was focused more on crops (Nkonya et al.; Pender et al.). However, in other cases, such as in the Amhara Region (Ethiopia), credit is associated with declining livestock numbers or income, probably because livestock must sometimes be sold to repay crop loans in situations of bad harvest or low prices (Benin; Jabbar et al.). Thus, there are important downside risks to the use of credit, especially where crop production is very risky.

Credit availability is also associated with greater investment in woodlots and improved fallow in Uganda, perhaps because credit enables farmers to take a longer-term perspective in their planning decisions, rather than due to any direct financing of these investments (Jagger and Pender). However, access to credit is associated with lower use of some non-purchased inputs, such as manure in Uganda and investment in stone terraces and incorporation of crop residues or household refuse in Amhara (Benin; Jagger and Pender; Nkonya et al.).

Predictions of bio-economic models are consistent with many of these findings. Access to credit is predicted to significantly increase adoption of purchased inputs and incomes in areas having relatively high rainfall and good soils, such as central Ethiopia (Ahmed et al.; Holden et al.), though investment in soil and water conservation is reduced, thereby

contributing to increased erosion (Holden et al.). In central Uganda, where the technologies considered are not very profitable, credit has less predicted impacts, though it increases adoption of rock phosphate leading to positive nutrient balances for phosphorus at the cost of greater depletion of other nutrients (Woelcke et al.).

Local organisations have significant but varied impacts on livelihood strategies and land management.

In Tigray, members of marketing co-operatives have higher crop productivity and earn substantially higher crop and total household incomes than other households (Pender et al.). Households with members that participate in a women's and youth association or as cadres earned less crop incomes and more of other kinds of income. However, these organisations had insignificant impacts on total household income. Consistent with the low crop income, members of a women's association use less oxen power and improved seeds than other farmers in Tigray. Members of an agricultural cadre, on the other hand, use less labour and improved seeds and obtain lower crop yields, but higher returns from livestock. Village council members farm more intensively in Tigray than other households, using more labour, improved seeds, manure, contour plowing and intercropping and less burning to prepare fields (Pender et al.). Greater presence of local organisations is associated with more effective collective action to manage communal grazing lands and less use of hired guards (Berhanu et al.).

In Amhara, households who are members of a service co-operative use more fertiliser and are more apt to incorporate crop residues, but use less labour and less manure than other households (Benin). In Kenya, households active in local organisations are less likely to use fertiliser, but are not significantly different from other households in their adoption of other land management practices (Swallow and Wangila). In Uganda, adoption of improved maize varieties in the lakeshore region is enhanced by membership in organisations (Sserunkuuma), while involvement in community and service organisations in Uganda has a positive association with manure use but a negative association with incorporation of crop residues, use of improved fallow and investment in woodlots (Jagger and Pender). It is difficult to simply characterise such complex results; the impacts of local organisations on livelihoods and land management appear to be context-dependent.

Land tenure has mixed or insignificant impacts on land management, productivity and resource conditions.

Land tenure insecurity appears not to be a major concern in either northern Ethiopia or in Uganda (Benin; Nkonya et al.; Pender et al.). In Tigray, sharecropping is associated with lower input use and yields, possibly as a result of restrictions by the regional government on the duration of land leases (Pender et al.). Similar inefficient sharecropping is absent in the Amhara region (Benin) or the Oromiya region (Pender and Fafchamps 2001). Although sharecropping and other land leasing lead to less intensive land use in Tigray, it does not undermine investments in soil and water conservation, partly because much of these investments are made by community labour mobilisation campaigns and partly because landowners also make investments on leased-out land (Pender et al.). Probably as a result, land tenure is not significantly associated with differences in perceived land degradation in Tigray.

In Amhara, land redistribution (which has continued in this region since 1991 but not in Tigray or Oromiya) has had significant impacts on livelihoods and land management. Land redistribution has helped to equalise oxen ownership, increasing the proportion of households keeping one or two oxen, but reducing the proportion of those owning more than two oxen (Jabbar et al.). It has also increased use of crop residues as animal feed and increased pressure on grazing lands (Jabbar et al.). Land redistribution has also contributed to increased use of fertiliser and reduced tillage but less labour and manure use in Amhara, probably because the younger and poorer households receiving the land own fewer oxen (Benin). Although land distribution has affected various land management practices, it has had an insignificant impact on crop yields (Benin).

In Uganda, many differences exist in crop choices and land management among different land tenure types, though the results are not clearly related to land tenure *per se* (Nkonya et al.). In general, the Uganda results do not support the often presumed superiority of freehold over customary or other tenure forms, since in many cases the adoption of improved technologies and yields were found to be lower, and perceived problems of erosion more severe on freehold plots (Nkonya et al.). Neither did the results show that owner-operated plots are managed more efficiently or sustainably than leased-in plots. Thus, land lease markets appear to function fairly efficiently in Uganda and most of Ethiopia (except Tigray, probably due to restrictions on leasing).

Education affects land management, livelihood strategies and outcomes in complex ways, and trade-offs are apparent among objectives of agricultural intensification, improved incomes and sustainable land use.

In Tigray, more educated households rely more on cattle as an important source of income, use more labour and oxen power per hectare but less fertiliser and improved seeds, obtain higher crop yields, but perceive more erosion problems than other households (Pender et al.). Participants in literacy campaigns in Tigray earn more livestock income and higher per capita incomes (Pender et al.), suggesting that these campaigns can help address poverty, while formal schooling has no significant impact on incomes.

In Amhara, more educated households are less likely to use manure, contour plowing, or incorporate crop residues, but are more likely to use improved seeds (Benin). More educated household heads are less likely to rely on cattle as an important source of income in Amhara (Jabbar et al.). As in Tigray, formal education has insignificant impacts on differences in incomes in Amhara (Jabbar et al.). Similarly, in Oromiya, education has an insignificant impact on livestock numbers and household income (Jabbar et al.).

In Uganda, more educated households earn higher incomes from the main perennial crops (coffee and bananas), livestock, and non-farm activities and total income, but less income from maize, beans and sorghum (Nkonya et al.). More educated households use less fertiliser and manure, more slash and burn, and obtain lower yields for several crops (Nkonya et al.). Thus, in Uganda, education appears to cause a trade-off between more intensive land management and higher non-farm income. Improvements in access to education through the Universal Primary Education policy may be one of the factors limiting agricultural intensification in Uganda. In Ethiopia, education has less measurable impact on incomes and agriculture, probably because education is more limited

than in Uganda. However, education may still be causing trade-offs between intensification and land degradation in Ethiopia too.

Impacts of households' livelihood strategies and endowments

Farmers' choices of livelihood strategies substantially influence their land management decisions and welfare and resource outcomes. Welfare outcomes are generally better for households pursuing livelihoods beyond food crop production (e.g. cash crops, dairy, tree products and non-farm activities), while there are mixed impacts of livelihoods on resource conditions, with trade-offs between income and resource outcomes common.

In Tigray, households for whom cereals production was the secondary source of income (mainly households with significant non-farm income) invested more in stone terraces, probably because they have higher incomes and can afford to hire labour (Pender et al.). However, land degradation was perceived to be a greater problem by these households than most others (Pender et al.). Other households with significant, though secondary, non-farm income also earn higher incomes than those households dependent on crop production. Many of these households use less intensive practices (less labour and oxen power) but are more apt to adopt improved seeds, and perceive more land degradation problems (Pender et al.).

Bio-economic model results also predict substantially higher incomes but more erosion resulting from farmers having greater access to off-farm employment opportunities in one area of Amhara, as a result of diminished incentives to invest in soil conservation (Holden et al.). Greater dependence on tree planting also could substantially increase incomes, with less negative impact on soil conservation and erosion (Holden et al.). In the Oromiya region of Ethiopia, perennial crop producers earn higher incomes (Jabbar et al.).

In Kenya, households producing cash crops (mainly in Central Kenya) earn substantially higher incomes, have better quality houses and are more prone to invest in land improvements than food crop-oriented producers (Place et al. (a) and (b)). Dairy producers and farmers having woodlots also have better quality houses in Kenya (Place et al. (b)).

In Uganda, farmers more dependent on non-farm activities are less prone to use improved fallow or plant woodlots (Jagger and Pender). Among smallholder producers in Uganda, fertiliser is used mostly on maize, while manure use is more common for cassava and crop rotation and incorporation of crop residues more common for millet (Nkonya et al.). Crop diversity was also associated with less food insecurity in eastern Uganda. In central Uganda, agricultural productivity and incomes could increase substantially if farmers produced more fruits and vegetables, but this is predicted to increase soil nutrient depletion under current market conditions (Woelcke et al.). The shift to commercialised maize production in central Uganda is also increasing soil nutrient depletion, particularly as improved seeds are used to increase yields without significant adoption of soil fertility replenishment technologies (Sserunkuuma).

Gender differences have important implications for livelihoods and land management in Ethiopia but less so in Kenya or Uganda.

In Tigray, female-headed households are more likely to rely on non-farm activities and less likely than their male-headed counterparts to depend on cattle for income; use less labour, manure and plowing; obtain lower crop yields and crop income; earn lower total household incomes; and perceive greater problems of declining soil fertility (Pender et al.). In Amhara, female-headed households are also more dependent on cereal production, and earn less crop income and total household income (Jabbar et al.). One of the reasons that female-headed households perform poorly in crop production in Ethiopia is because women are often not allowed to plow, putting them at a serious disadvantage as farmers (Aune et al.).

In Uganda, little difference exists between female-headed and male-headed households with regard to land management practices, livelihood strategies and incomes, after controlling for other factors, though female-headed households attain lower yields for some crops (Jagger and Pender; Nkonya et al.). Similarly, in Western Kenya, no significant differences were observed in land management practices between female and male-headed households (Swallow and Wangila). Cultural restrictions appear to play a less significant role in affecting crop production of female-headed households in Kenya and Uganda than in Ethiopia.

Livestock can have substantial positive impacts on livelihoods, land management and incomes, though these impacts vary significantly over time and space and some trade-offs are apparent.

In Tigray, larger size of livestock owned (especially of cattle) is associated with higher labour and draft animal use in crop production, greater use of manure or compost, contour plowing, improved seeds and fertiliser, less use of reduced tillage, higher crop productivity, improvement (or less decline) in soil fertility, higher crop income, higher livestock income, and higher total and per capita income (Pender et al.). High marginal returns (greater than 30%) to investment in cattle, poultry and beekeeping were found in Tigray. Greater heterogeneity in oxen ownership is associated with more violations of grazing land restrictions in Tigray, indicating that inequality of wealth or interests can cause the breakdown of community institutions for managing common property resources (Berhanu et al.).

In Amhara, larger size of oxen owned is associated with more use of draft animal power, fertiliser, seeds and manure; less investment in terraces and live fences and, surprisingly, more reduced tillage (Benin). Livestock had negative marginal returns in Amhara in 1999, due to the drought in the preceding year (Jabbar et al.). In Oromiya, cattle and small ruminants yield substantial positive marginal returns, contributing to significantly higher household incomes (Jabbar et al.).

In Western Kenya, greater oxen ownership is associated with greater use of manure and crop rotation (Swallow and Wangila). In Uganda, livestock ownership is associated with greater use of manure (Jagger and Pender; Nkonya et al.; Sserunkuuma) and fertiliser (Nkonya et al.) and cattle ownership is positively associated with incorporation of crop residues and investments in improved fallow and woodlots (Jagger and Pender). Livestock in general earn positive marginal returns—some small livestock (chickens and pigs) earn marginal gross returns of greater than 100%—and livestock ownership is associated with

higher household income in Uganda (Nkonya et al.). However, livestock are also associated with more perceived erosion in Uganda (Nkonya et al.).

Thus, livestock contribute to generally positive outcomes for agricultural intensification and land management (especially in promoting manure use) and incomes in the East African highlands, though some trade-offs are apparent, such as negative impacts on land investments in Amhara and a positive association with erosion in Uganda. The negative returns to livestock in Amhara in 1999 also indicate that livestock are a risky asset (though perhaps not more risky than crop production) in drought-prone areas.

Impacts of land management practices

Inorganic fertiliser use is profitable in some areas of the highlands, particularly areas with higher rainfall and better soils, and also has substantial impact on agricultural production. In areas with poorer soils or lower rainfall, fertiliser is generally less profitable and, thus, not widely adopted.

In recent years, fertiliser use has been heavily promoted in the Ethiopian highlands and has had substantial impact on increasing crop (especially maize) yields in higher rainfall areas. Fertiliser use increased crop yields by more than 60% on average in the highlands of Amhara region (Benin). Bio-economic model results from higher rainfall, high market access areas of central Ethiopia also predict good returns on fertiliser use (Ahmed et al.; Holden et al.). In drier areas such as the semi-arid highlands of Tigray, however, fertiliser use has not been profitable, despite evidence of increased yields (Pender et al.).

In eastern Uganda, experimental results show that fertiliser use is highly profitable for maize production on better soils in higher rainfall areas, but much less on poorer soils and lower rainfall areas (Kaizzi et al.). This finding is supported by experimental results from the Tororo district of Uganda (good soils and sufficient rainfall), and where NP fertiliser more than doubled maize yields (Delve and Ramisch). Survey results in Uganda, also found high returns to fertiliser use for maize and coffee, though with limited number of plots in high potential areas (Nkonya et al.). By contrast, fertiliser had limited impact on maize yields and was less profitable in experimental sites in central Uganda (Woelcke et al.).

Alternative low-external input soil fertility management technologies yield higher returns than inorganic fertiliser in many cases.

A relay rotation with *mucuna* (velvet beans) cover crop earned higher returns than fertiliser in most sites in eastern Uganda (Kaizzi et al.). Kaizzi et al. also found that using more than 40 kg/ha of N produced little additional yield and reduced profits. Use of biomass transfer (*tithonia*) is more profitable than fertiliser use in Western Kenya and eastern Uganda, though the highest yields were found by combining the two approaches (Delve and Ramisch). Rock phosphate is more profitable than processed fertilisers in the central Uganda sites (Woelcke et al.). Mulching and crop rotation are associated with higher bean yields in Uganda, while integrated pest management is associated with higher yields of maize, coffee and cassava (Nkonya et al.). In Tigray, higher returns to investments in stone terraces, use of manure and compost, and reduced tillage than use of fertiliser

and improved seeds were found (Pender et al.). Manure use also provides substantial yield benefits in Amhara (Benin). The benefits of zero tillage have been confirmed by experimental trials in the Ethiopian highlands, which found higher yields on plots where zero tillage was used than where traditional tillage practices were used (Aune et al.). Area enclosures (community lands temporarily protected from grazing or other use) also provide substantial economic returns in the Ethiopian highlands (Aune et al.).

The profitability of alternative land management practices is not universal.

Most practices were not significantly associated with higher crop yields in Uganda, and some were associated with lower yields (Nkonya et al.). Application of farmyard manure is not profitable and had little impact on maize yield in experiments conducted in central Uganda (Woelcke et al.). Soil organic matter is relatively high in many of the soils in this region (Ssali) and, thus, organic inputs may have limited benefit, especially if not managed carefully to ensure adequate nitrogen (Nkonya et al.). Contour plowing, reduced tillage, crop rotation and incorporation of crop residues have insignificant or negative impacts on yields in Amhara (Benin). Even where alternative practices such as improved fallow or biomass transfer lead to increased yields, they are sometimes not profitable because of the loss of one or more cropping seasons or the labour costs associated with the practices (Delve and Ramisch; Kaizzi et al.). Such practices are more likely to be profitable where population pressure is at an intermediate level, so that farmers can still use a fallow system but need to intensify production, and/or when niches (such as field boundaries) can be used for producing soil-fertility enhancing plants (Delve and Ramisch).

Several low-external input land management technologies also contribute to improved resource conditions, though this is not universal.

In Tigray, manure and compost use are associated with farmers' perceptions of reduced erosion, while contour plowing is associated with improved soil fertility (Pender et al.). Zero tillage helps reduce erosion and soil nutrient depletion and sequester carbon (Aune et al.). Improved fallows using a leguminous cover crop contribute to positive balances of nitrogen at the cost of shortfalls of other nutrients (such as phosphorus) as yields and hence outflows of these nutrients increase (Delve and Ramisch). Similarly, use of rock phosphate leads to positive balances of phosphorus, although it depletes other nutrients (Woelcke et al.). Positive nutrient flows can also contribute to water pollution problems if leaching is a problem. Thus, a balanced nutrient management approach is needed. Some practices, such as incorporation of crop residues, are associated with more perceived erosion, probably due to increased turning and soil exposure (Nkonya et al.). Ethiopian farmers associate reduced tillage with lower soil fertility, but this may reflect an inaccurate perception that tillage is necessary to manage fertility (Pender et al.).

Soil and water conservation investments are often complementary to improved soil fertility management practices, but substitution between investments and fertility management also occurs.

In Tigray, the presence of stone terraces is associated with greater use of fertilisers, probably because the terraces help conserve soil moisture and reduce nutrient losses, both of which increase the efficiency of fertiliser use (Pender et al.). In Amhara, stone terraces and live fences are similarly associated with greater application of manure and

household refuse, probably for the same reason (Benin). Tree planting is associated with greater adoption of reduced tillage in Tigray, possibly because trees and roots increase the difficulty of tillage (Pender et al.). Soil and water conservation structures are also associated with greater fertiliser use, tree planting with more manure, and water harvesting structures with green manures in Western Kenya (Swallow and Wangila). On the other hand, Holden et al. note that increased adoption of fertiliser reduces farmers' investment in soil and water conservation structures by helping to mask the negative effects of soil erosion on yields. Thus, it is not clear whether investments in soil and water conservation and improved soil fertility management always go together, since one may substitute for the other to some extent.

Implications

These findings amply demonstrate the complexity of factors affecting livelihoods and land management and the diversity of responses to any given factor in the East African highlands. The search for simple solutions to the complex problems of land degradation, low and declining agricultural productivity and poverty is probably in vain, and dogmatic pursuit of approaches that have succeeded in some settings is likely to fail in others. Common policy recommendations, such as building roads or irrigation schemes, reduce population growth, provide freehold land rights, redistribute assets, increase access to credit, invest in education, promote local organisations, promote fertiliser use, or promote low-external input technologies have all been shown to have impacts that are highly context-dependent, often limited in scale, sometimes surprising, and that commonly involve trade-offs among objectives.

Sometimes 'win–win' outcomes—increasing agricultural productivity and human welfare while improving natural resource conditions—are possible, as has been observed in the Central Kenyan highlands as a result of favourable access to a large urban market, infrastructure, technical assistance and credit. However, these favourable set of circumstances and outcomes appear to be the exception rather than the rule in the East African highlands. Often trade-offs must be contemplated, such as the negative effect of improved education on agricultural intensification in Uganda, despite (or because of) the substantial positive impacts on incomes (especially non-farm income). The existence of such trade-offs should not however discourage policy makers from investing in public goods such as education to improve livelihood options and welfare. They should instead be an encouragement to consider ways to minimise the negative impacts on other important outcomes where they occur. For example, incorporating lessons on the principles of sustainable agriculture and land management, basic economic analysis and profitable opportunities in agriculture in the primary and secondary school curriculum could help improve land management. In the long run, education is likely to reduce population pressure on land by taking rural people out of land-based livelihoods.

Some general lessons can be drawn from this complex set of findings. One is the importance of farmers' access to reliable information about profitable economic op-

portunities and suitable technologies that are demand-driven rather than top–down. The success of technical assistance programmes in Uganda in promoting the adoption of improved land management technologies, income diversification and higher household incomes is an example of what can be achieved. More effort is, however, needed to expand the reach of such programmes, especially to more remote areas. In Ethiopia, the government extension and credit programme has been more widespread and remarkably successful in promoting increased use of inorganic fertiliser. This has had a major impact on food crop production, especially maize in higher potential areas. However, this approach has failed to improve farmers' incomes in lower rainfall areas such as Tigray, contributing to increased hardship in many cases by encouraging farmers to accept loans that they will have difficulty to repay. Extension programmes should try to learn from farmers as well as other sources what opportunities are profitable and sustainable with acceptable risks in a given situation, rather than trying to promote a pre-defined set of technologies everywhere. To help ensure that extension programmes are demand-driven, it would also help to separate regulatory and technical assistance roles, so that extension agents or their supervisors are not expected to enforce land use or land management policies.

Information about prices, market opportunities and technologies is important. Improvements in the market information system can help improve the integration and efficiency of markets, and increase the profitability of adopting more sustainable land management practices (Rashid; Woelcke et al.). Expansion of input demand through better market and technical information can help achieve economies of scale in transportation and marketing, potentially leading to significantly lower input costs (Woelcke et al.).

A second lesson is that credit can help promote more sustainable development and land management if it is used to promote profitable livelihood opportunities and technologies, as in Central Kenya. However, credit can also be risky for farmers, especially when used to promote fertiliser or other risky inputs in drought-prone environments, and should not be excessively promoted as a panacea or overly restricted in its use. To the extent that credit becomes available for a wider set of uses and longer duration, it can help facilitate profitable alternative livelihoods (such as non-farm businesses, intensive livestock or horticultural production) or longer term investments (such as planting trees) that may yield better returns and reduce pressure on degraded lands more effectively than promoting intensification of food crop production. On the other hand, credit may lead to less intensive land management if it promotes non-farm activities. Provision of credit and extension programmes and other policies to promote agricultural production can also promote expansion of agricultural area at the expense of forests, and which has negative environmental consequences, as has been observed in Zimbabwe (though the effects of such policies on deforestation were limited) (Minde). Thus, a flexible and demand-driven approach to credit that is linked to the identification of profitable opportunities, can help facilitate improved livelihoods, but may have mixed impacts on land management and resource conditions.

A third lesson is that traditional land tenure systems do not appear to be major constraints to more sustainable land management in the East African highlands. Thus, changes in these systems are unlikely to yield major benefits in general. Land tenure

insecurity was not found to be a major concern, and in some cases management of lands under customary tenure appears to be at least as good as land under freehold tenure. These findings echo the findings of numerous other studies on African land tenure systems (Dione). However, to the extent that freehold tenure can increase farmers' access to credit, then, where credit is an important constraint (such as in high potential and high market access areas of Uganda where increased production of cash crops has strong potential), changes in tenure can yield significant benefits, regardless of the degree of tenure security under traditional systems.

A fourth lesson is that population pressure and poverty do not appear to be insurmountable constraints to promoting improved livelihoods and more sustainable land management. The research has shown that high population density, small farm sizes, lack of livestock or other assets often have a small and insignificant impact on land management and incomes. In some cases, these constraints contribute to the adoption of more intensive land management practices, as argued by Boserup and her followers. More often, these constraints are overcome by the functioning of factor markets; i.e. markets for land, labour, oxen-power and other productive inputs.

Even where land sales markets are prohibited, as in Ethiopia, land lease markets can function well to equalise farmers' access to land and crop income. The functioning of such markets can, however, be undermined by policy interventions such as the restrictions on the duration of land leases in Tigray. Such restrictions should be avoided unless there is a compelling reason for using them. In Ethiopia, some policy makers argue that lease restrictions are needed to prevent small farmers from being exploited by large farmers or land speculators seeking to consolidate landholdings. Although this may be a legitimate concern in some areas, there is little evidence to show that land consolidation is a general concern in rural Ethiopia. In most cases, leasing or share-cropping of land is used by households with little access to land to improve their access and economic opportunities, while leasing portions of land is used by households without sufficient endowments of complementary productive inputs such as oxen or labour (especially by female-headed households), and also to improve their livelihoods.

A fifth lesson is the importance of investment to achieve sustainable development. Although poverty is not an insurmountable obstacle to development, finding pathways out of the downward spiral of land degradation, low agricultural productivity, poverty and food insecurity requires identifying and facilitating socially profitable investments (public and private). The findings demonstrate that profitable investments exist in the East African highlands, even in less-favoured areas such as the highlands of Tigray (e.g. high returns to some low-external input land management practices, some livestock and tree planting). The profitable mix of investments depends on the comparative advantages of particular locations, which vary substantially across the East African highlands due to variations in agricultural potential; access to markets, roads and other infrastructure; population pressure and other factors. Thus, no 'one-size-fits-all' strategy will work for all of the East African highlands.

In areas with high rainfall and good soils, as in much of central, western and southern Ethiopia, Central and Western Kenya and eastern Uganda, returns to intensified crop production using inorganic fertiliser and other inputs can be quite high, and develop-

ment strategies should capitalise on this potential. Technical assistance programmes should focus on identifying and promoting profitable levels of use of fertiliser as well as complementary land investments and land management practices in these areas. Where access to markets and roads is also good, promoting a shift to higher value crops such as vegetables and fruits or intensive dairy production can yield high returns, and help promote the adoption of improved land management practices. The success achieved in Central Kenya is a primary example of the benefit of shifting into higher value commodities and adopting improved land management practices. In such areas, programmes to expand credit access and complementary institutional interventions (such as provision of land titles or improvement of credit recovery through the establishment of a credit reference bureau, small claims courts etc.) can help address credit constraints and increase the adoption of high value commodities.

Where there is high agricultural potential and relatively good proximity to a large urban or foreign market, but limited road access, investments in rural feeder roads can be a high return investment enabling higher value agricultural production and associated investments in land improvement. However, the relatively limited and mixed impacts of road access in Western Kenya, Ethiopia and Uganda demonstrate that road development alone does not always have bigger positive impacts, even in areas of high agricultural potential. The size of the market for higher value products (much larger in Nairobi than in Kampala or Addis Ababa) is important, as is access to complementary services, such as technical assistance, credit and transportation. Thus, bundling of complementary public investments and programmes is needed to achieve the potential for higher value production.

To the extent that the promotion of increased cereal crop production in higher potential areas is successful (as it has been recently in much of the East African highlands), this tends to depress farm prices and may cause farmers' incomes to decline, especially if they are net sellers of grains (though consumer surplus will increase), leading to economic hardships for some and pressures to support prices. While these problems can be serious, increased production and falling prices of cereals also create opportunities to develop the livestock feed industry, other agro-processing, agricultural exports, increased food stocks and food security, and domestic or regional sources of food aid. For investors to make the investments needed for these opportunities to be realised, it is helpful to limit perceived risks by demonstrating the commitment of policy makers to facilitating this strategy. For example, sudden large subsidised export (or import) shipments, unsustainable price support policies, or changes in the technical assistance approach to reduce surplus production could undermine investors' confidence. In addition to avoiding such policy-induced risks, governments and external donors should help ensure private investor confidence by making complementary public investments in infrastructure (e.g. roads, electricity, telecommunications) in areas with good potential for agro-industrial development and sharing some of the risks of private investments (e.g. through investment guarantees or equity sharing).

Such developments in higher potential areas can also enable agricultural development in lower potential areas, which have less comparative advantage in intensified crop production. As cereals and associated fodder supplies become more available, this can

enable farmers in lower potential areas to invest in other more profitable activities, such as intensified production of livestock (e.g. feeding of grain to poultry, pigs or dairy cattle), higher-value annual or perennial crops (especially where irrigation is available), tree products, or non-farm activities. Most of these alternatives will be more suited to areas closer to urban markets, though, as is the case of Ethiopia, less perishable perennial crops such as coffee can be produced further from markets. Returns to investments in small-scale irrigation, roads and credit programmes can be high in areas where these potentials exist. Investments in education may enable households to participate in non-farm activities, as has been observed in Uganda.

To the extent that such alternative activities are adopted, new opportunities as well as constraints for sustainable land management become relevant, and should be taken into account in technical assistance programmes promoting improved land management. For example, intensified livestock operations will increase the supply of manure, which can be used in intensive horticultural crop production. Investment in trees can reduce the shortage of fuelwood and fodder and enable greater recycling of manure and crop residues to the soil. At the same time, increasing non-farm income opportunities may reduce farmers' willingness to invest in labour-intensive land management practices, as is apparent in Uganda and predicted to occur in Ethiopia. Such changes in opportunity costs and constraints should be considered in development and technical assistance strategies. In the long term, however, improving non-farm opportunities are critical to absorb excess labour from the agricultural sector, reduce pressure on natural resources and achieve sustainable improvement in incomes and welfare.

In lower potential areas that are more remote from markets, the comparative advantages are more in livestock and tree products production, as in Tigray, though improvement of food crop production cannot be ignored since high transport costs and low incomes limit the ability of farmers to afford imported food in such areas. Investments in several low-external input technologies have been shown to yield fairly high returns in cereal production in such areas, and technical assistance programmes should identify and promote such profitable options. There may be profitable opportunities to use limited amounts of fertiliser and other modern inputs together with soil and water conservation and other low-external input approaches. However, research and greater learning from farmers' experiences are needed to help identify these opportunities. Regardless of what is done to exploit these opportunities, however, poverty and land degradation are likely to continue to be severe in such areas without productive livelihood opportunities for people to migrate to (temporarily or permanently) as well. Investments in education and vocational training programmes and assurance of land tenure security for those who emigrate are thus critical components of a sustainable development strategy for such less-favoured areas.

Taking advantage of opportunities for improved livestock or tree production, or the widespread adoption of some improved land management technologies, such as reduced tillage, may require changes in community institutions (as well as regional or national policies and regulations), such as institutions regulating the management of communal lands and the free-grazing system in Ethiopia. Changes in such institutions can lead to serious conflicts and dislocations, and should be considered carefully before decisions

are made by governments to promote or enforce such changes on a wide scale. In many cases, such changes can come about through institutional innovation or evolution at the local community level (if not prevented by policy restrictions), though institutional inertia may also prevail even if institutional change is likely to improve the welfare of the community (North 1990). Governments can play a constructive role in helping foster such welfare-improving institutional change if they are not too heavy-handed and do not undermine local initiatives, but rather try to facilitate changes that communities identify as being in their own interests. Pilot experiments in Tigray allowing communities to allocate degraded hillsides for private tree planting activities are one example of a government helping to facilitate beneficial local institutional change. A similar approach could be considered to encourage experimenting with changes in the free grazing system and improving the management of community grazing lands.

In summary, many opportunities exist to promote improved livelihoods and land management in the East African highlands. The prospects for breaking out of the downward spiral of land degradation, low productivity and poverty are good. However, the task is not easy. Changes in policies, programmes and institutions will be needed that are well suited to the comparative advantages of different locations, taking into account the diversity of circumstances in the East African highlands. There is also the need to recognise that the same intervention can have different impacts in different circumstances, that complementary interventions may need to be bundled together to be most successful, and that trade-offs among desirable outcomes are often likely. These will help policy makers and development agencies to achieve better results and maximise the potential of the region and its peoples.

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Overview of discussions

S. Benin,[a] P. Jagger[b] and Zeleka Paulos[a]

a. International Livestock Research Institute (ILRI), Ethiopia
b. International Food Policy Research Institute (IFPRI), USA

Introduction

Bringing policy makers, researchers, donors and other stakeholders together can have enormous rewards in information sharing, articulating needs and identifying promising policies. However, inherent challenges also exist when these groups meet. Researchers often focus on the technical aspects of models, whereas policy makers look for brief synopses of research findings that can be translated into effective policy prescriptions. To focus discussions during the three days of the conference, some participants emphasised that the policy implications of the research findings, rather than methodological and other analytical issues, should be the focus of the presentations and discussions. This was deemed important due to the general feeling that past research has had little impact. As one participant questioned, how can the research be good if it cannot have impact on reducing land degradation, increasing agricultural productivity, alleviating poverty and increasing food security? In light of this, the discussions provided many important insights on how to increase the impact of policy research and specific policy implications with respect to land management in the East African highlands and several other areas where refinement of the research may be useful.

How to enhance the research impact

Several mechanisms were discussed to improve the impact of the research findings of the project on policies for sustainable land management in the East African highlands. It was agreed that the research needs to be demand driven by farmers, policy makers, development practitioners and other stakeholders. For example, involving government agents (especially ministry level civil servants) from the onset of research projects may lead to increased impact. Allowing key civil servants (for example, those that provide the link between ministers, field level extension agents and farmers) to identify research questions may ensure a demand driven approach to research, as well as increasing the likelihood that policy recommendations will be heard and internalised by policy makers. It is equally important for stakeholders to be clear about the types of research they need. On this point, conference organisers explained that the research project on 'Policies for sustainable land management in the East African highlands' has tried to involve all stakeholders in setting the research agenda. Several meetings and workshops were held throughout the duration of the project to keep people involved and informed. However,

as research is an interactive process, it will take time to notice its impact. The greatest impact will likely be through capacity building of local partners by providing them with the information on a level that can be translated by them into policy briefs for policy makers as well as the tools to follow up with their own research.

An important aspect of stakeholder participation is that of farmers and the degree to which they participate. It was noted that farmers' participation should go beyond answering survey questions to involvement in the interpretation of research findings, especially the puzzling ones. It was suggested by several conference participants that researchers need to go back to communities and engage farmers in interpreting the data and confirming findings. It was also noted that plans to organise a workshop at the zonal level in the Tigray region of Ethiopia to discuss the research findings with community leaders and farmers will help fulfil this goal.

The need for researchers to effectively package and market their products (policy prescriptions) was also highlighted by policy makers. In addition to providing policy briefs that are concise and reader friendly, some participants also argued that researchers should be actively involved in policy dialogue and lobbying. Providing policy recommendations alone is generally not enough to precipitate changes. Although the 'Policies for sustainable land management in the East African highlands' project has benefited from good interaction between researchers and policy makers through the National Advisory Committees in Uganda and Ethiopia, it was noted that more needs to be done.

The issue of to what extent policy makers have effectively expressed their information needs to researchers and/or made use of the available research findings and policy recommendations was also raised by some participants. Perhaps policy makers find the policy recommendations to be risky, as one policy maker voiced his concern regarding the applicability of the policy recommendations and suggested the need for pilot experiments to further validate the recommendations. Researchers indicated that, as they try to plan future research related to policies for sustainable land management in the East African highlands, they want to know what policy makers need to know. Researchers also indicated that they are looking for opportunities to build on on-going research and to introduce policy experiments in pilot areas. Two examples of such experiments that can be immediately targeted are: the allocation of degraded hillsides for private tree planting in the Tigray region of Ethiopia, and the National Agricultural Advisory Services (NAADS) that lead pilot extension programmes in Uganda.

On the issue of conducting pilot studies, concern was raised as to the possibility of conducting experiments on issues that are restricted in the constitutions of governments. For example, a pilot project to experiment with private land holding is not feasible in Ethiopia, where land sales are constitutionally prohibited. Such experiments will thus have to be conducted within constitutional constraints. Although the sale of land is prohibited in Ethiopia, informal land transactions (renting) are taking place and their impacts are being investigated.

Policy implications

The discussions on policy implications centred on land policy and tenure, extension and credit, human capital, programmes and organisations, infrastructure and promising technology options for agricultural transformation. Most of these issues are relevant to policies to improve land management throughout the East African highlands region.

Land policy and tenure

Land tenure issues in Africa are complex. The research findings did not support the notion that informal and customary tenure systems are inefficient and that free holding of land must prevail. Findings from Ethiopia and Uganda indicate that informal land tenure systems can be efficient. Therefore, it was argued that these findings should be considered when developing or revising land redistribution or titling systems.

On the other hand, the finding that agricultural productivity was higher and land degradation lower on mailo and customary tenured land in Uganda should not be interpreted to mean that these forms of tenure are superior to freehold.[1] The mailo system covers areas closest to Kampala, which provides better access to domestic and international markets. This proximity may be responsible for the high intensity and commercialisation of agriculture on mailo land, as compared to freehold land. Since freehold tenure in Uganda was not actually intended for the security of tenure (but rather for the devolution of land rights and to increase farmers' access to formal credit), clarity about the concept of tenure security is critical. Furthermore, given that tenure security may be more problematic especially where there is lack of good governance, the focus should be on land rights. It was also argued that there is the need to make land rental markets more dynamic, as restrictions such as on the terms of leasing that exist in the Tigray region of Ethiopia can lead to inefficiencies. In Tigray, although land leasing may be extended for up to 10 years according to the official land proclamation,[2] survey analysis indicates very few examples of land leases extending longer than 2 years. This is probably due to the rule that land leases can only be extended for up to 2 or 10 years depending on whether the lessee is using 'traditional' or 'modern' technology, respectively. However, there is little clarity as to what constitutes the respective categories of technologies.

The proposal by the United Nations Economic Commission for Africa (UNECA) to conduct a study on land tenure in southern Africa attracted several suggestions. It was recommended to extend the study to West and East Africa. A suggestion was made to try

1. In central Uganda, the mailo system of land tenure is most prevalent. Under this system, colonialists gave land to notables and elite in the early 1900s. The individuals receiving this land often lacked the means to till the area so they began settling tenants. In 1928, these tenants received eviction protection so that they could not be forcibly removed from the land without compensation. Only mailo owners have the opportunity to acquire titles to the land, but the tenants have strong rights to the land as well. Some mailo farmers exist today, but the majority of individuals occupying the land are the tenants.
2. One of the participants hinted that a recent amendment to the proclamation has extended this up to 20 years.

to involve some of the many land tenure specialists participating in the conference. The proposed research should look at the review of land tenure systems in sub-Saharan Africa (SSA) that has been put together by the University of Wisconsin, and also try to link with the ongoing project on land tenure in four African countries, including Ethiopia and Tanzania. It was also recommended that the UNECA convene a conference on land tenure to address the key ideas and issues.

Extension and credit

It was noted that the evidence that extension is having a positive impact on agricultural productivity in the higher potential areas of the Ethiopian highlands and Uganda lends support to Uganda's Poverty Reduction Strategy Paper (PRSP) for identifying extension as a key area for government investment. However, the returns to investment in agricultural extension still need to be clearly identified and articulated in an impact assessment. Such an assessment should address issues such as potential off-farm externalities. For example, encouraging farmers to use larger quantities of inorganic fertiliser can lead to environmental pollution. In Uganda, increasing fertiliser use on maize, which is not a good cover crop, is contributing to eutrophication in Lake Victoria. Thus, a proactive approach that incorporates environmental awareness into extension packages is needed. Furthermore, some participants noted that the lack of livestock extension information and public veterinary service has implications beyond crop and livestock productivity at the household–farm level, as there is a trend of increasing oxen sharing among farmers that is resulting in more disease outbreaks, ultimately reducing farmers incomes and their asset holdings.

The limited impact of micro finance on long-term agricultural productivity growth and livelihoods was discussed. This may be due to the fact that a very limited amount of the available credit is targeted at agricultural production, and focused on fertiliser adoption (in Ethiopia) rather than the adoption or acquisition of other inputs that contribute to long-term sustainability. In addition, farmers often borrow for consumption purposes rather than for production inputs or investment. Thus, broadening the focus of credit and linking it to adoption of land management technologies, providing relevant training and following up will be important aspects of developing an effective and sustainable credit system. However, farmers alone cannot be blamed, as governments have in many instances used micro credit to achieve political goals, ignoring proper utilisation and recovery of the credit, which has contributed to low recovery rates. Putting in place a legal framework to protect both micro finance institutions and borrowers will be important, especially if private lending institutions are to be promoted.

Human capital

The power of education is one of the emerging themes of this research that many participants felt should be a key focus of policy makers. Education has enormous potentials to relieve pressure on the natural resource base by moving people out of

agriculture. This would allow a portion of non-farm incomes to be invested in land management and agriculture to increase productivity. In the short term, however, investment in education may undermine the intensification of agriculture, as more 'educated and skilled' farmers move out of agriculture.

By affecting labour supply, HIV/AIDS also has immense implications for land management in general. Although the research has not addressed the issue of HIV/AIDS directly, it was argued that the importance of identifying and developing technologies that have lower labour requirements is apparent.

The issue of gender was also raised by many participants as very important, as women contribute a great deal of labour to on-farm activities and, in many cases, head households. Yet, it was argued that there seems to be little focus by agricultural extension or non-governmental organisation (NGO) networks on women in the East African highlands. Thus, policy makers should consider taking Kenya's example, where extension messages are designed as gender sensitive. In addition, there needs to be more emphasis on education for girls and women, family planning and increased opportunities for and access to infrastructure by women.

Programmes and organisations

Non-governmental organisations (NGOs) are not just a source of information. They also facilitate information exchange that leads to the adoption of land management technologies such as improved fallow. The linkage may be indirect, but it is still significant. Similar research in Central America suggests that the best approach may be for programmes and organisations to get involved in community services and poverty alleviation to initially help people out of poverty and gain their trust. Only then is it possible to succeed in promoting land management technologies. People are more likely to adopt land management technologies once the initial pressures of poverty are alleviated. Programmes and organisations may have the greatest impact by focusing on areas that farmers are most concerned about. This is particularly important where high discount rates contribute to short planning horizons. In these situations, undertaking land management activities that are unlikely to yield returns in the short run may not be their most pressing priority.

On the other hand, it was argued that households may act strategically, as other evidence from two villages in the Tigray region of Ethiopia indicates that households invest more on their moderately degraded lands, because at the community level mass mobilisation tends to be on their worse off lands. Sustainability issues arise in much of the Ethiopian highlands where people are spending all their assets and not investing.

Although the evidence showed that collective action programmes seem to be working well especially in the highlands of Tigray region, some participants raised concern about the sustainability of these success stories of collective action as they are linked to mass mobilisation/mandatory work. Whether or not smallholders continue to engage in the management of community grazing lands and woodlots in the absence of mandatory

work-days is unknown. Evidence of institutional constraints with respect to accessing woodlot benefits indicates that this type of collective action may not be sustainable.

Infrastructure

Some participants argued that market liberalisation policies have not achieved substantial transformation in agriculture and increase in productivity, due to the limited market infrastructure. Beside roads and communication systems, market development requires compiling data, disseminating information and reducing information asymmetries. These types of data are costly to compile, upgrade and maintain. It was argued that the Ethiopian case of price crashes and large increases for various commodities in different regions are definitely associated with problems of poor infrastructure development.

Several issues need to be resolved to improve the infrastructure base. For example, donors want to see vehicles, as an indicator of demand and potential returns to investment, before they are willing to invest in roads. However, there is a significant causality problem, particularly in highland regions; without roads there will be no vehicles. In addition, there are apparent contradictions in some of the policy recommendations. For example, encouraging public investment in roads while at the same time stopping deforestation appear to be competing policy goals. Evidence from Uganda indicates that improvements in road access had a positive effect on livelihoods. However, improved road access was also accompanied by increased deforestation. Kenya faces a similar paradox; only 2% of the forest area is gazetted and so where forest margins exist roads will most likely lead to deforestation. Although all stakeholders are looking for win-win outcomes, it may be necessary to consider accepting some substitutions and trade-offs, while looking for opportunities to minimise the trade-offs. In general, the research needs to be extended to include further analysis about the constraints to market development (roads, information dissemination and access etc.) and the costs of addressing those constraints.

Land management technologies

Although it is not possible to transform agriculture into a commercial activity everywhere, there are various technologies that different systems can adopt to address the poor and declining resource base. It was emphasised that maintaining and improving soil fertility is crucial for raising and maintaining agricultural production if any hope of transformation of the rural economy in the East African highlands (and SSA in general) is to be realised. Fortunately, there are many technologies that can be fine-tuned and made available to fit within farmers' cultural practices.[3] The use of Tithonia, for example, has been highly recommended and is quite advantageous to farmers for

3. Note that although there are many land management technologies, the discussion among conference participants on this subject referred to the specific technologies that were studied and presented at the conference.

increasing soil fertility, although there is a problem of biomass production and transportation. Growing Tithonia on the farm (e.g. around field boundaries) is one way of overcoming the biomass constraint as well as reducing the transportation cost. However, there is the need to examine the costs and benefits of using Tithonia, and using it with other technologies. Another promising technology is *mucuna*, which is a good source of nitrogen and has good ground cover. In addition, it has more biomass production than Tithonia. A problem with *mucuna*, though, is that it climbs maize stems and causes the plant to fall.

The Regional Land Management Unit (RELMA) is advocating conservation (zero, minimum or reduced) tillage and, if applied regionally, believes it will have many benefits including reducing erosion and increasing productivity. Although conservation tillage is relatively common for cash crops, it is not well advanced in broadcast crops such as teff, which, due to its very small seed size, requires repeated plowing. It was pointed out that zero tillage may be valuable for female-headed households (especially in Ethiopia where women are not allowed to plow) and labour-constrained households (such as those affected by HIV/AIDS). However, zero tillage on vertisols, which are common in the Ethiopian highlands, can be very difficult due to soil compaction problems, though reduced tillage on vertisols has worked very well around Holleta in Ethiopia and is especially favoured by young farmers.

Some participants argued that zero or reduced tillage does not prepare the land as well as ox plowing does, and also results in weed problems. As weed killers are expensive to import, hand hoes can be used for weeding on smaller plots of land (less than 0.5 ha). We should not lose sight of the fact that although the above low-cost fertility technologies (and many others including crop rotation, manuring, composting, plowing in crop residues, fallowing etc.) are useful, many of them are recycling techniques and do not necessarily improve fertility, and can be costly when used alone. Thus, given the severe negative nutrient balances of most soils in SSA, with East African soils losing more than 60 kg of NPK per hectare each year, complementary use of inorganic fertilisers is crucial.

Some participants also argued that zero or reduced tillage has implications for the livestock sector. For example, reduced tillage has been promising in Tigray, where there have been higher returns to investments in cows than in oxen, suggesting that a shift to more productive and profitable herd composition may be important, provided marketing channels are developed. Evidence from Asia lends support to this shift. For example, in India, dairy development occurred after draft power requirements were decreased in mechanised areas. Also, in South-East Asia, there was a shift from buffalo to pigs and poultry, as rural economies became more market oriented. Other lessons from the rural transformation of Asia and work by John Mellor shows that continuously introducing technologies that will increase yields may be the way out of the downward spiral.

Some participants felt that the role of trees in land management was not clearly articulated. People cut trees to generate cash income to purchase fertilisers etc., but there are many other ways (both positive and negative) that relate trees to land management and these need to be further explored. With respect to collective action, there is the

need to look more closely at the heterogeneous nature of communities and the level of resource dependence in the community, especially with respect to community woodlots where no harvesting is allowed.

Directions for future research

The project on 'Policies for sustainable land management in the East African highlands', is centred around the concept of development pathways. Though a powerful conceptual framework for identifying livelihood strategies that capitalise on relative comparative advantages, it was argued that there is a need to incorporate structural change into the framework. For example, how does the development pathways paradigm handle the type of changes that have occurred in the Gojjam area of Ethiopia where there is a revolution in maize production and prices have plummeted? In addition, the concept of 'market access' needs to be disaggregated beyond low and high market access, as market access is an inherently complicated variable influenced by more than access to the nearest road or market. Disaggregating the various components of market access (e.g. distance to nearest all-weather road or market), size of market (e.g. population of nearest urban centre), direct international export potential and distance to export port etc. may prove useful in further understanding success stories in places such as the Machakos district in Kenya.

With respect to the analytical methods, a lot of emphasis was placed on advanced econometric and modelling techniques, which participants felt was impressive. Regression analysis is a powerful tool as it provides a great deal of information about how various factors influence land management and livelihoods, holding other factors constant. It is also very revealing when it comes to identifying patterns of change. However, the potential role of other forms of rigorous social analyses was highlighted as a mechanism for increasing the policy impact of the research project. Policy makers in particular emphasised the likely role of social science disciplines like economic history, sociology, anthropology and political science as compliments to the econometric methods that have dominated the research to date. Borrowing methods from other social science disciplines was suggested as a good way to gain a more in depth understanding of some of the cultural, institutional and social issues that underlie economic decision-making. In addition, using other types of economic techniques such as cost–benefit analysis to estimate the relative profitability of various technologies would provide important information to policy makers. It was also noted that the analysis was limited to the use of cross sectional data, which makes it difficult, for example, to understand and replicate development pathways. In general, there is a need to do further research by utilising other methods based upon time series data analysis, complimented by historical, sociological and anthropological research.

Welcoming and opening addresses

Welcoming address

J. Dione

Director, Food Security and Sustainable Development Division (FSSDD)
United Nations Economic Commission for Africa (UNECA), Ethiopia

Mr Chairman
Honourable ministers
Distinguished guests
Dear colleagues and friends from co-sponsoring institutions of this conference
Ladies and gentlemen

It is a great pleasure to have you here at the United Nations Conference Centre (UNCC) to attend this important conference on 'Policies for sustainable land management in the East African highlands'. On behalf of the Executive Secretary of the United Nations Economic Commission for Africa (UNECA), I am indeed honoured to welcome all of you. We at UNECA are indeed glad to be associated with the International Livestock Research Institute (ILRI) and other partner institutions in this venture.

The concerns addressed by this meeting are at the core of major development challenges facing Africa today. Indeed, one of the daunting challenges of the continent is to meet the food needs of its rapidly growing population while preserving the quality and the productive capacity of its natural resource base. All recent projections indicate that Africa is the only region of the world where the number of poor and hungry people will continue to grow in the next decades. If not reversed, these trends will inevitably lead to further degradation of natural resources.

African experts and their counterparts need to come up with imaginative solutions to address the cluster of issues resulting from the critical interactions between current demographic, agricultural and environmental trends. The synergetic effect of these interactions, as we are all aware, contributes to increasing poverty further, compounding the hardships imposed on the populations by natural disasters such as drought and flood.

It is generally admitted that agricultural activities constitute the main causes of land degradation in rural Africa. This is due not only to population pressure, but also to inadequate practices, low level of technology and the increasing use of marginal lands.

The negative trends depicted above should be addressed boldly in the context of the continent's vast endowment of natural resources, much of which remains untapped. It is possible to curb these negative trends through harnessing the benefits of new technologies, including biotechnology and precision agriculture. Some success has been already achieved in African agriculture. It is fortunate that the International Food Policy Research Institute (IFPRI) is implementing a major project aiming at putting such success cases on record, so as to facilitate the dissemination of resulting best practices.

Dear participants

In order to achieve sustainable development, appropriate policies and strategies on natural resource management, particularly in marginal areas, need to be developed and put in place. This requires a clear understanding of ways of preventing the mining of natural resources.

The Sustainable Development Division (SDD) of UNECA, since its establishment in 1997, has been conducting a series of studies to assist African countries in the analysis and management of the nexus issues of the linkages between population, agriculture and environment. The division has just completed a study on the state of the environment in Africa, and will undertake two major studies during the next two years on the 'state of food security' and the 'impact of land tenure systems on food security and sustainable development in Africa'.

Distinguished guests, ladies and gentlemen

The theme and objectives of this conference are well in line with the quest for solutions to the problems of natural resource degradation in Africa. There is no doubt that the findings of the remarkable research work that has been carried out over the past few years on 'Sustainable land management in the East African highlands' will provide greater understanding and insight into the issues pertaining to sound policies for poverty reduction and sustainable development in the region.

On this note of confidence, I wish all of us successful deliberations in this conference.

Thank you.

Welcoming address

J. Pender

Senior Research Fellow
International Food Policy Research Institute (IFPRI), USA

Mr Chairman
Honourable Vice Minister Ato Belay Ejigu
Honourable Minister Dr Kisamba-Mugerwa
Honourable Minister Madame Grace Akello
Distinguished guests and colleagues

On behalf of the International Food Policy Research Institute (IFPRI), it is a great honour and pleasure for me to welcome you to this conference on 'Policies for sustainable land management in the East African highlands'.

IFPRI is one of sixteen Future Harvest Centres of the Consultative Group on International Agricultural Research (CGIAR). Established in 1975, IFPRI's mission is to help developing countries identify and implement policies and strategies to reduce poverty and ensure food security for all people, while ensuring sustainable use of natural resources.

Since 1996, IFPRI, in partnership with the International Livestock Research Institute (ILRI) and regional partners, has been working to plan and implement research on sustainable land management in the East African highlands. In early 1997, we held a regional workshop at ILRI, cosponsored by IFPRI, ILRI, the African Highlands Initiative and the Soil, Water and Nutrient Management Programme of the CGIAR, to discuss problems of land degradation and develop an agenda for policy research on priority research areas that were identified. Based on that workshop, and several subsequent planning workshops at national and sub-national levels in Ethiopia and Uganda, IFPRI and ILRI initiated policy research on sustainable land management in partnership with universities, national agricultural research institutes, ministries and bureaus of agriculture, finance and planning in these countries, university partners from Europe and the United States and other collaborators. This conference will review and discuss findings from that research, as well as several years of other related research programmes that have been conducted in the East African highlands.

As most of you know, land degradation, low agricultural productivity, food insecurity and poverty are severe problems facing the more than 90 million people living in the East African highlands. These problems are interrelated, and in many areas are leading to a downward spiral of land degradation and impoverishment. The main objective of our research has been to identify pathways out of this downward spiral, considering potential technology, policy and institutional interventions. We, along with the other cosponsors of this conference and their partners, have learned a great deal about the extent and causes of these problems and potential ways out.

I will not try to anticipate all of the findings and discussions to come over the next three days. However, I expect that among the main themes that will emerge will be the following:

1. There are profitable opportunities for more sustainable development and land management in the East African highlands.
2. Exploiting these opportunities will require investments in an appropriate portfolio of physical, human, natural and social capital.
3. The appropriate strategy for investments, policies and institutions must be suited to local comparative advantages; there is no 'one-size-fits-all' strategy that will work throughout the diverse circumstances of the East African highlands.

I want to extend my sincere thanks to:

- The United Nations Economic Commission for Africa for hosting this conference and serving as a cosponsor of the conference
- The other conference cosponsors, including ILRI, the International Centre for Research in Agroforestry, the Eastern and Central Africa Programme for Agricultural Policy Analysis, the African Highlands Initiative, and the Soil, Water and Nutrient Management Programme of the CGIAR, and the Regional Land Management Unit of the Swedish International Development Cooperation Agency
- Many organisations and their representatives from the region and outside who are partners in this research, including Mekelle University, the Ethiopian Agricultural Research Organization, Ethiopian regional bureaus of agriculture and planning, Makerere University, the National Agricultural Research Organisation of Uganda, the Agricultural Policy Secretariat of Uganda, the Agricultural University of Norway, the Centre for Development Research of the University of Bonn, Wageningen University and Research Centre, Purdue University and others
- The governments of Switzerland, Norway, Germany, Italy, The Netherlands, the United States, the United Kingdom and Japan, who are providing financial support to IFPRI's and ILRI's research on sustainable land management in the East African highlands
- The many staff of ILRI and IFPRI who have organised the conference and are taking care of logistical details and
- Particular appreciation is due to the many officials, community leaders and farmers who have graciously and patiently participated in the research.

Without the active interest and participation of leaders and farmers from the region, this research would not have been possible. I hope that the research and this conference will help policy makers to develop strategies to better serve these leaders and farmers in their quest to eliminate poverty and land degradation in the East African highlands. I wish us all success in this effort.

Thank you.

Welcoming address

I. Minde
Co-ordinator
Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), Uganda

Mr Chairman
Honourable ministers
Distinguished delegates
Ladies and gentlemen

First of all, please allow me to pass on greetings from Dr Seyfu Ketema, the Executive Secretary of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA). ASARECA is the executing agency of the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), one of the co-sponsors of this conference. Ethiopia being his home country, Dr Seyfu Ketema would have liked to be here with you but due to pressing commitments he was not able to make it. However, he requested me to inform the conference that the theme of the conference is very close to his heart. ASARECA has in its goal, sustainability of the natural resource base. One of the ways to achieve part of this goal is to have very clear and sustainable policies for land management. Such policies will provide confidence to users and hence encourage them to invest in the land. It is important to repeat the fact that sustainability is to be derived not from the natural resource itself but from people. The management (by the people) factor is, therefore, critical in achieving sustainability. ASARECA attaches so much importance to this issue that it has two of its networks entirely devoted to this task. These are the African Highlands Initiative (also a co-sponsor of this conference) and the Soil and Water Management Network. This does not in any way suggest that the other networks and programmes are oblivious of the natural resource base and the environment in their work. It is only that these two networks take natural resource as their core business.

Mr Chairman, there are two points that I would like to emphasise. These points are in many ways mutually reinforcing.

The first point is the need to organise and manage our work towards impact. It is very important for each researcher or scientist to be conscious of how and what is being implemented, will lead to or contribute towards impact. And impact is broadly defined here to mean making a positive change at individual level. This could be by way of improving food security, increasing incomes or contributing towards a more sustainable natural resource base. Most of the work that we are involved in is crafted towards solving specific problems facing society. Because of resource constraints, there are very few studies that could be categorised as basic or fundamental research. The work needs, therefore, to be organised in such a way that the problem is solved. To accomplish that we need, for example, to be aware of how the work of an individual scientist is linked to

the project work and how the project work is linked to the programme work and so on and so forth. These linkages are necessary because often times the work of individual scientists may not be sufficient to solve a problem.

The second point that is also worth emphasising is to take policies as being made at all levels of society. There is often a misconception that policies are only made by policy makers at the ministerial or cabinet level. In the context of the work that has been done for this conference for example, there are policies that can also be made at the community level. A community can decide, within its mandate, how it wants, say, a community forest to be managed and used. The community can also set some bylaws, provided that this is done within the context of the national law.

I did say that these two points are mutually reinforcing because a piece of research geared towards impact may have as part of its objective positive policy changes at various levels. If that research is able to change a particular policy at the community level, then, that is part of the impact.

I wish all of you a wonderful three days of learning.
Thank you.

Welcoming address

F. Place
Economist
International Centre for Research in Agroforestry (ICRAF), Kenya

On behalf of the International Centre for Research in Agroforestry (ICRAF) and the African Highlands Initiative, I wish to welcome all of you to this conference. ICRAF has conducted research and development throughout the region for over ten years. The African Highlands Initiative is also working in five countries in eastern Africa. The range of areas is too large to mention, but briefly we work on technological, institutional and policy options for addressing the key problems of natural resource degradation and poverty.

I wish to thank the United Nations Economic Commission for Africa for hosting the conference and organisers from the International Food Policy Research Institute (IFPRI) and the International Livestock Research Institute (ILRI). I know that I have hardly done anything to make the workshop happen, so IFPRI and ILRI must have done a lot of work.

I also wish to thank all the donors and particularly the Regional Land Management Unit (RELMA) for covering the travel costs of the Kenyan participants from research institutions and government.

These types of events provide great opportunities. Such gatherings of people with similar interests, but diverse experiences, are rare and I look forward to not only the discussions within the conference, but in the more informal periods outside of the conference. I am also excited to have in our presence people who are in or have been in government and who not only appreciate the role of research, but also still conduct research. Some of them will be presenting their work to us.

We have a big job to do because when I drive around the highlands I see enormous potential and opportunity. There are some very successful agricultural production systems in the highlands, but many areas have high poverty rates, low agricultural productivity and degrading resource bases.

I know that what will be presented at the conference is not all the valuable work taking place in the highlands. Many of the people in this room have other valuable experiences and others who have conducted research may not even be in attendance. But I am sure that our discussions will take our thinking forward.

We have an important job to do. Let us remember that the issues are complex and solutions have eluded us in the past. There is no single easy way forward and let us not shy from discussion on issues. We all need to contribute ideas and challenge those statements that we do not agree with.

With these remarks, I will stop and wish us all success.

Opening address

Belay Ejigu

Vice-Minister, Ministry of Agriculture
Government of the Federal Democratic Republic of Ethiopia

Your Excellencies
Honourable Dr Kisamaba-Mugerwa, Minister of Agriculture, Animal Industries and Fisheries of Uganda
Honourable Madame Grace Akello, State Minister of Labour and Social Development (Entandikwa), Uganda
Sponsors of the conference
Representatives of regional governments
Honourable guests, ladies and gentlemen

It is a great honour to welcome you and address this distinguished gathering at the regional conference on 'Policies for sustainable land management in the East African highlands'.

Low agricultural productivity, poverty and land degradation are critical and closely related problems in the Ethiopian highlands. The principal causes of low and declining agricultural productivity and extreme poverty in the Ethiopian highlands are land degradation including soil erosion, soil nutrient depletion and moisture stress.

These problems are worsened by harmful farming practices such as farming on steep and fragile slopes, limited use of fallow land, limited recycling of manure and crop residues, limited biomass cover and others.

Underlying these proximate causes are numerous factors such as population pressure, poverty, land fragmentation, limited access to favourable market outlets and infrastructure, limited farmer awareness of sustainable land management practices and policies affecting these factors.

Honourable guests, ladies and gentlemen

Improving land degradation remains critical in enhancing the welfare of the rural population. Seeking to understand the underlying causes and to identify strategies to achieve more sustainable land management practices, and to reduce poverty and food insecurity in the Ethiopian highlands, the International Livestock Research Institute (ILRI) and the International Food Policy Research Institute (IFPRI) in collaboration with local partners from Mekelle University, regional bureaus of agriculture and planning and the Ethiopian Agricultural Research Organization have been implementing a research project on 'Policies for sustainable land management in the highlands of Ethiopia' for the past four years.

The project has been implemented in the three national regional states of Tigray, Amhara and Oromiya. The study has come up with several important findings. Results of the study indicate that population pressure has a negative impact on natural resource conditions in the highlands. Better market access, credit services, and technical assistance programmes can have positive impacts on land improvements and resource and welfare conditions, indicating that 'win-win' development strategies can reduce land degradation and poverty and increase agricultural productivity.

However, the strategies need to be tailored to local conditions. In low rainfall environments such as much of Tigray, responsiveness to fertiliser and improved seeds has been found to be less than in high rainfall areas. Other strategies, such as promoting soil and water conservation measures, investing in afforestation and livestock development have been found to yield substantial returns. Population policy/programmes have been identified as one of the priority intervention areas, and efforts made so far in this regard, together with provision of improved market access, have resulted in encouraging outcomes. Involving local communities in natural resource management has been found to be more sustainable and beneficial in areas with intermediate population that are far away from towns. Literacy will no doubt contribute towards more sustainable development in the highlands.

Although these findings are very useful, it will be important to develop some pilot policy experiments to test 'on the ground' some of the findings before we scale up to many regions in the country.

Honourable guests, ladies and gentlemen

At this juncture, permit me to express my appreciation to the sponsors of the conference and also for all who contributed to the realisation of this conference, and wishing you all success in your deliberations, I now declare this conference open.
Thank you.

Background, objectives and activities

Policies for sustainable land management in the East African highlands: Conference background, objectives and agenda

S. Ehui

International Livestock Research Institute (ILRI), Ethiopia

Background

Initial planning of the research project (1996–98)

- Literature review, consultations, field visits
- Participatory planning workshops
  - National workshop in November 1996
  - East African regional workshop in February 1997
  - Regional workshops in Tigray, Amhara, Oromiya in 1997 and 1998
- Key problem areas identified: soil erosion, soil fertility depletion, overgrazing and deforestation
- Key policy issues: impacts of land policies, market policies, infrastructure, research, extension, conservation measures and decentralisation/governance

Initiation of project

- Late 1997 in Tigray region
- Late 1998 in Amhara and Oromiya regions

The goal of the research project is to contribute to improved land management in the East African highlands, in order to increase agricultural productivity, reduce poverty and ensure sustainable use of natural resources. The immediate purpose of the research project is to help policy makers identify and assess policy, institutional and technological strategies to improve land management in the East African highlands. In order to increase awareness of the underlying causes of land degradation problems and promising policies and strategies for solving the problems, we promised our donors and stakeholders to hold a regional conference at the end of it all. And so here we are.

Objectives

1. To review, discuss and synthesise the findings and policy implications of research related to sustainable land management in the East African highlands regions

2. To increase the awareness of policy makers and other stakeholders on the impacts of policies, programmes and other factors on land management, agricultural productivity, poverty and food security
3. To discuss promising strategies to promote more sustainable land management, increased agricultural productivity, and reduced poverty and food insecurity and consider priorities for policy action and further research.

Co-sponsors

- International Food Policy Research Institute (IFPRI)
- International Livestock Research Institute (ILRI)
- Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA)
- International Centre for Research in Agroforestry (ICRAF)
- African Highlands Initiative (AHI)
- Soil, Water and Nutrient Management Programme of the CGIAR
- United Nations Economic Commission for Africa (UNECA)
- Regional Land Management Unit of the Swedish International Development Cooperation Agency

Agenda

Wednesday, April 24

- Session 1: Opening session, chair S. Ehui, Co-ordinator, Livestock Policy Analysis Programme, ILRI
- Session 2: Development domains and strategies in the East African highlands, chair Honorable Dr W. Kisamba-Mugerwa, Minister of Agriculture of Uganda
- Session 3: Development pathways and land management in the East African highlands, chair Dr Tenkir Bonger, Prime Minister's Office of Ethiopia

Thursday, April 25

- Session 4: Case studies on development pathways and land management, chair Honorable Grace Akello, Minister of State for Labour and Social Welfare (Entandikwa), Uganda
- Session 5: Factors influencing land management in Ethiopia, chair Dr Aberra Debelo, Deputy Director General, Ethiopian Agricultural Research Organization, (EARO)
- Session 6: Factors influencing land management in Uganda, chair Mr Chebet Maikut, President of the Uganda National Farmers Federation

Friday, April 26

- Session 7: Factors influencing land management and food security in other countries, chair Dr Willis Oluoch-Kosura, Head of Agricultural Economics Department, University of Nairobi
- Session 8: Impacts of land management practices, chair Mr Charles Gashumba, Director of Agricultural Policy Secretariat of Uganda
- Session 9: Modelling impacts of alternative policies and technologies, chair Dr John Lynam, The Rockefeller Foundation
- Session 10: Concluding session on policy implications, lessons learned and future research needs, chair Honorable Ato Belay Ejigu, Vice Minister of Agriculture of Ethiopia

Policies for sustainable land management in the East African highlands: Research background, objectives, conceptual framework and activities

J. Pender

International Food Policy Research Institute (IFPRI), USA

Introduction

- Problems of low agricultural productivity, land degradation, poverty and food insecurity are severe in the East African highlands
- Low agricultural productivity
  - Cereal yields of 1 t/ha or less in most areas
  - Yields declining in many places
- Land degradation
  - Soil nutrient losses greater than 80 kg of NPK/hectare each year estimated in Ethiopia and Kenya, nearly 70 in Uganda
  - Average erosion of 42 t/ha each year in Ethiopian highlands
  - One-half of Ethiopian highlands moderately to severely eroded
- Poverty and food insecurity
  - Most households subsist on less than 1 ha of land and US$ 1 per day

These problems are interrelated and can lead to a downward spiral, as shown in Figure 1.

Proximate causes of land degradation are well known, including:

- Deforestation
- Overgrazing
- Limited soil and water conservation measures
- Limited applicants of nutrients/organic matter
- Burning of dung and crop residues

Underlying causes—hypotheses

- Population pressure
- Poverty
- Landlessness and smallholdings
- Limited physical, human, financial and social capital
- Limited access to markets, infrastructure and credit

- Land tenure insecurity, land fragmentation
- Lack of awareness of technological options
- Policies affecting these factors

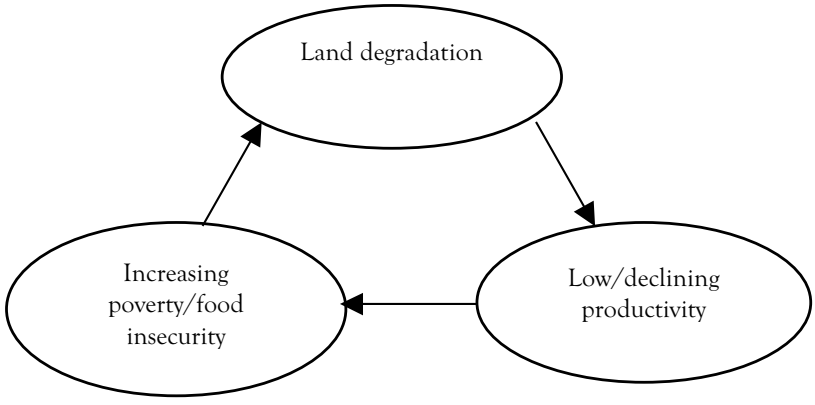

Figure 1. *Interrelated problems of land degradation, low productivity and poverty.*

Research goal, purpose and objectives

Long-term goal: To contribute to improved land management in the East African highlands, in order to increase agricultural productivity, reduce poverty and ensure sustainable use of natural resources.
Immediate purpose: To help policy makers identify and assess policy, institutional and technological strategies to improve land management in the East African highlands.

Specific objectives

- To identify the main factors affecting land management and its linkages to agricultural productivity, poverty and sustainability
- To identify the major current and potential pathways of development, their causes and implications
- To identify and assess strategies to promote more productive, sustainable and poverty-reducing pathways of development and improved land management
- To strengthen the capacity of collaborators in the East African region to develop and implement such strategies, based upon policy research
- To increase awareness of the underlying causes of land degradation problems and promising strategies for solving the problems.

Conceptual framework

Many factors potentially affect farmers' decisions about livelihood strategies and land management, and a complex set of linkages exist between government policies and these decisions. The conceptual framework, illustrated in Figure 2, guiding this research has been developed to address these challenges.

Land management is determined by private decisions made at the farm household level, as well as by collective decisions made at the village or higher levels. These household and collective decisions determine current agricultural productivity and affect the condition of land resources (thus influencing future agricultural productivity), which in turn affect the level of farm income and rural poverty. It is such outcomes (productivity, resource conditions and household incomes), and not adoption of specific land management practices *per se*, that are likely to be of most concern to rural people and to policy makers. The ultimate impacts of any policy or technology on these outcomes, and the extent to which there may be trade-offs or complementarities among these objectives are thus considered critical. A strict regulatory approach, for example, prohibiting farmers from planting annual crops on steep lands, may be effective in reducing soil erosion, but may also have severe implications on agricultural production, food insecurity and poverty. On the other hand, there may be 'win-win' strategies available that promote greater productivity and incomes as well as improved resource conditions. For example, promoting intensification of annual production on less steep lands and perennial production on steep lands may reduce land degradation, while increasing agricultural productivity and farm incomes.

Land management decisions are determined by many factors operating at different scales (plot, household, village, region, nation and international). Many of these factors influence land management directly. Demographic and socio-economic factors—such as population density, access to markets and the level of local prices—also influence land management. Some of these effects are direct, while others are indirect. For example, access to markets and local prices determine the profitability of alternative practices. On the other hand, population pressure leads to smaller farm sizes and often to more fragmented holdings, which may reduce farmers' ability or incentive to fallow or undertake land-improving investments.

One important indirect way in which biophysical and socio-economic factors affect land management is by determining what livelihood strategies have comparative advantage in a particular location and for particular households. For example, in areas close to a major urban market and high agricultural potential, farmers may be able to earn relatively high incomes from production of perishable cash crops (such as horticultural crops) or intensive dairy production. The land management problems, constraints and opportunities for improved land management in such a situation (e.g. declining soil fertility, potential for use of inorganic fertilisers or livestock manure, potential benefit of credit) are likely to be significantly different than in more remote areas where less intensive subsistence mixed crop–livestock production may predominate (e.g. opportunities for improved fallows, need for improved management of common

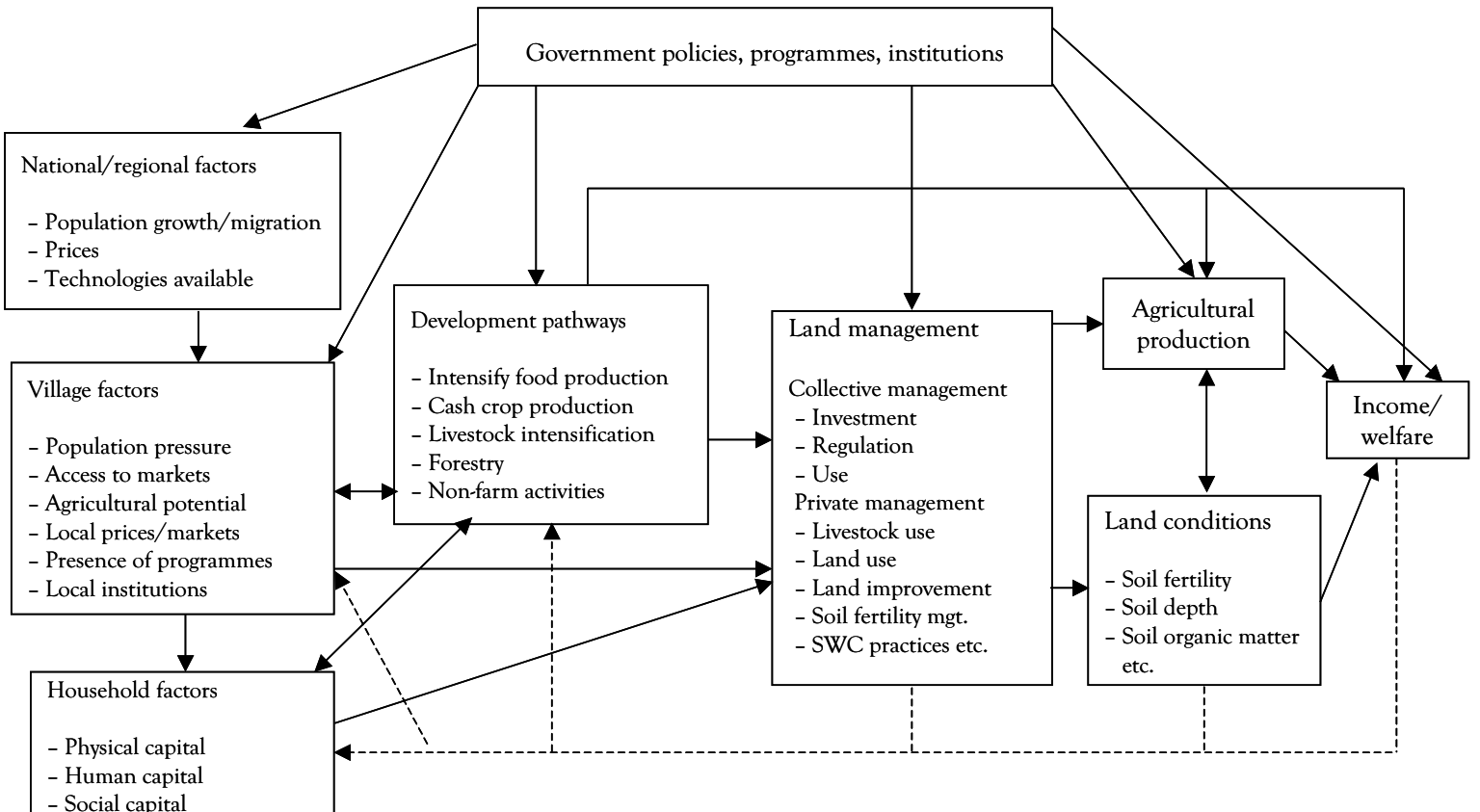

Figure 2. *Factors affecting livelihood strategies, land management and their implications.*

grazing lands, appropriate technical assistance to improve both livestock and crops). The appropriate policy strategies for such situations are therefore also likely to differ.

The development of different livelihood strategies in a particular location may be influenced by many village level factors, such as agricultural potential, access to markets, population density, and presence of government programmes and organisations. These factors largely determine the comparative advantage of a location by determining the costs and risks of producing different commodities, the costs and constraints to marketing, and the opportunities and returns to alternative activities, such as farming versus non-farm employment. These factors may have generalised village level effects on livelihood strategies and land management, such as through their impact on village level prices of commodities or inputs, or they may affect farm household level factors, such as average farm size. Household level factors such as households' endowments of physical capital (e.g. land, livestock), 'human capital' (education, training, farming experience, household size and composition), 'social capital' (participation in community organisations, leadership in community), 'financial capital' (access to credit, savings), or 'natural capital' (land quality, access to other resources) may also determine the livelihood strategy or land management practices chosen by particular households.

Government policies, programmes and institutions may influence livelihood strategies and land management and their implications for productivity, sustainability and household incomes at many levels. Macro-economic, trade and market liberalisation policies affect the relative prices of commodities and inputs in a nation. Agricultural research policies affect the types of technologies available and suitable to farmers in a particular agro-ecological region. Infrastructure development, agricultural extension, conservation, technical assistance programmes, land tenure policies and rural credit and savings programmes affect awareness, opportunities, or constraints at the village and household level. Policies or programmes may seek to promote particular livelihood strategies (e.g. food crop production), or may seek to address constraints arising within a given livelihood strategy (e.g. credit needs arising in cash crop production). Programmes may attempt to address land management approaches directly, for example by promoting particular soil fertility management practices. Policies and programmes may also be designed to affect development outcomes directly, through direct management of land by the government, or through nutrition or income enhancement programmes.

Currently available information does not provide policy makers with much guidance on effective intervention points to achieve better land management, improve agricultural productivity and increase incomes and food security. Much public action aimed at improving land management focuses on influencing household adoption of particular technologies. Yet this may be ineffective if the technologies are not suited to the livelihood strategies that have comparative advantage in a given location. It may be more effective in many cases to first focus on the larger development strategies for particular livelihood strategies, before focusing too much on particular land management technologies.

Activities

- Characterisation of the land degradation problem and development of hypotheses using secondary information
- Community surveys to identify pathways of development, their causes, and implications for land management
- Household and plot-level surveys to assess impacts of policies and other factors on land management and implications
- Farm level soils characterisation and experimental work to better understand farmers' options and implications of alternative land management practices
- Household bio-economic models to explore the potential impact of alternative policy, institutional and technological strategies.

Summary of papers and discussants' comments

Development domains in East Africa and a spatially-based strategic planning framework for sustainable land use in Uganda

S. Wood and S. Bolwig

International Food Policy Research Institute (IFPRI), USA

Governments and development funders have a constant need for information that helps to improve the quality of their investment decisions. In addition, as investment decisions become more complex, so do the information needs. There is growing awareness in Africa, for example, that sustained economic growth can only be achieved by addressing the underlying causes of poverty, hunger and disease, and to do so will involve better formulation and harmonisation of development strategies. Furthermore, in a region where livelihoods depend overwhelmingly on agriculture and other resource-based activities, it is fundamentally important that development approaches internalise the dynamic interdependencies between the welfare of rural populations, and the condition of land, water and biological resources.

This paper describes a policy-focused evaluation framework being developed by the International Food Policy Research Institute (IFPRI) that focuses on these core concerns. The framework adds explicit treatment of livelihood strategies, technological change, markets and trade to assess the local and aggregate effects of livelihood choices and environmental policies on a range of welfare outcomes.

The origin of this research lies in a challenge that the Uganda Mission of the United States Agency for International Development (USAID) set in designing a new strategic objective targeted to increasing rural incomes. The 'Expanded sustainable economic opportunities for rural sector growth' strategic objective will be implemented over the period 2002–07 at a cost of some US$ 150 million. This new strategic objective is a combination of previously separate strategies and country programmes on enhancing agricultural productivity, market and trade development and improved environmental management. By design, the new strategic objective has brought sharper focus on addressing the growth–environment nexus in all aspects of programme design and implementation. However, it also required the development of a new conceptual framework that the Uganda Mission could use to justify and articulate its more integrated approach, and IFPRI was invited to assist in this task.

Through examining the purpose and relevance of the approach both within and beyond Uganda, a consensus was reached that the framework should be capable of generating policy and investment related information on the scope for improving rural livelihoods at a regional and national scale arising from:

- enhanced agricultural productivity, product diversification and better-informed and more effective marketing channels
- improved management and utilisation of forests, wetlands and other 'natural' ecosystems and natural resources and
- protection of the capacity of Uganda's natural resources and the ecosystems they underpin, to meet current and future demands for environmental goods and services.

It was recognised from the outset that the design and implementation of such a framework presents many conceptual and practical challenges. First is the need to integrate both quantitative and qualitative information about socio-economic and biophysical factors. Second is to strike a balance between the need to work at the level of information aggregation that is appropriate for policy dialogue, with the need to work at levels of disaggregation that capture the significant aspects of variability in biophysical and socio-economic conditions. Third is the challenge of limiting the complexity of any thematic component of the framework to that warranted by its influence on key analytical results.

One potential ally in meeting these challenges is geographical information systems (GIS) technology. Not only does the accessibility of GIS technology to development specialists continue to improve, but so too does its analytical potential. That potential is being realised through increased availability of geo-referenced (GIS compatible) data layers as well as more powerful and extensive spatial analysis tools. One example is the (now common) practice of geo-referencing individual plots and households when conducting trials and field surveys. Another is the increased availability and resolution of satellite-derived data on land cover and land cover change. A GIS also provides data management capacities that support the integration and interpretation of data in diverse formats, and serves as a useful tool for communicating findings to policy makers. It does so by providing insights to patterns and processes that might be less apparent in tabular data. Given these opportunities, and acknowledging the fundamental relevance of location from an agricultural and environmental perspective, the framework has been designed from the outset to be spatially explicit.

The IFPRI strategic planning framework

There are six underpinning concepts in IFPRI's approach. First, existing policies, opportunities, constraints and preferences lead individual households and communities to adopt specific livelihoods and associated land use patterns. Second, there are broader social objectives to safeguard land uses that provide valued (often public) goods and environmental services, such as drinking water, flood regulation, pollinators, wild game, recreation and so on. Third, by overlaying individually and socially preferred land use visions, it is possible to identify areas in which the two visions differ, as well as to establish the nature of those differences. Fourth, known options (inventories of technologies, land management options, institutional arrangements etc.) are examined to assess the extent to which individual and social preferences might both be satisfied at the

local level, or to establish the nature and scale of potential trade-offs involved. This step involves assessing the likely relative payoffs from alternate growth-enhancing land use options, benchmarked around the actual livelihood enterprises observed in Ugandan communities.[1] The analysis involves formal modelling of the likely economic benefits of alternative productivity improvement options, as well as a review of production, resource management and marketing constraints based on community, household and market survey data.

Fifth, the locally-preferred range of livelihood and associated land use options is assessed at the aggregate level to establish whether goals regarding income growth, poverty alleviation, export revenue, forest cover, wetland conversion and so on are achievable, and, if not, suggesting more compatible livelihood and land use choices. IFPRI is developing an agriculture-focused general equilibrium model to support this stage of the work. The model will help in exploring aggregate impacts of productivity enhancements and improved marketing chains on representative household groups, including feedback on employment and wages. It can also help assess the possible implications of a range of domestic and international policy, trade and technology scenarios.

In the sixth stage, the most promising locations and opportunities for some form of support or intervention are matched against the priorities of development funders. These might be donors (such as USAID), government agencies, or non-governmental organisations (NGOs). The goals and priorities of each of these development funders can then be compared with the most promising of the intervention options identified by the above process. Potential funders can, thus, apply the information generated by the analytical framework to better target their investments and planning studies with certainty that such interventions might also build towards nationally-determined socio-economic and environmental goals.

The application of the framework is still in its early stages. Still, some interesting results are emerging from spatial analyses relating especially to the first three concepts or steps. They identify, for example, areas with a comparative advantage for different agricultural intensification or expansion strategies; areas with high levels of biodiversity or fragile soils; and based on this information, areas of potential conflict or complementarity between agricultural development and environmental conservation. The analyses show that the areas where local communities most profitably can intensify agriculture are located in south-western Uganda and in a west to east widening band around Lake Victoria. Agricultural expansion is likely to occur in a band starting from the shore of Lake Albert and heading eastward to encompass the Lake Kyoga basin, and in much of the far north and northwest.

The potential environmental impacts of these locally-preferred scenarios were assessed using spatial information on soil conditions and biodiversity, including the geographical distribution of protected areas and threatened plant and animal species. In this regard, the areas with the highest conservation value were found in the central and

1. Drawing on Ugandan National Household Surveys and parallel IFPRI community, household and market surveys targeted to research on natural resource management and development pathways.

extreme western and south-western parts of the country and in a few other locations, such as Lake Bisina, Mt Moroto and along the River Nile in northern Uganda.

These analyses suggest, for example, that there are large areas in northern Uganda where agriculture may be expanded without very significant biodiversity losses; yet we also found many economically useful plant species in that region's natural ecosystems that could supplement agricultural incomes if conserved. In addition to the obvious humanitarian reasons, solving the conflict in northern Uganda could thus generate significant economic returns at relatively low environmental costs by enabling farmers to expand and develop their agricultural enterprises. The role of the public sector in this process would include: working with communities in protecting critical ecosystems services such as biodiversity, which are often seriously degraded during agricultural expansion; developing input and output marketing services in partnership with the private sector; and investing in physical infrastructure, especially rural feeder roads, to improve access to markets, technologies and services.

Pressures from agriculture on protected areas are likely to be found in south-western and extreme western Uganda, while the west-central (Luwero, Kiboga, Kibale and Masindi districts) and north-eastern parts of the country exhibit potential conflicts between agricultural expansion and the conservation of unprotected ecosystems such as wetlands, forests and woodlands. Agricultural intensification as it is currently occurring, without adequate replenishment of soil nutrients and limited use of soil conservation measures, is in potential conflict with soil conservation objectives, especially in the eastern region and in south-western Uganda. Conversely, it appears environmentally sound to intensify agricultural land use along the shores of Lake Victoria and in the extreme southeast of the country.

Village stratification for policy analysis: Multiple development domains in the Ethiopian highlands

G. Kruseman,[a] J. Pender,[b] Girmay Tesfay[a] and Berhanu Gebremedhin[c]

a. Wageningen University, The Netherlands
b. International Food Policy Research Institute (IFPRI), USA
c. International Livestock Research Institute (ILRI), Ethiopia

Introduction

Many countries in sub-Saharan Africa, including Ethiopia, suffer from interlinked problems related to poverty and natural resource degradation. The need to adequately address the formidable problems facing northern Ethiopia with the modest means available implies that choices have to be made on where to target specific activities. To get a handle on the possible differences, the notion of development domains is used. This concept hinges on the notion that it is possible to find common elements to any successful development strategy.

One of the main hypotheses of the development domains concept is the existence of differences in comparative advantages of alternative livelihood strategies, leading to different development pathways. Differences in comparative advantage can be attributed to three main factors: agricultural potential, market access and population density. Quantification of development domains has practical use. It allows a framework for further analysis needed to design development interventions appropriate for the target area. Within this framework of analysis many different approaches might be considered, ranging from econometric analysis of survey data to bio-economic modelling. Especially for the bio-economic modelling, a village stratification is important in order to construct the appropriate model with structural relationships reflecting the development domains.

This paper presents a method for stratifying villages into development domains using multivariate analysis of a broad community-based survey. The results from the analysis are used to draw conclusions in terms of policy implications.

Development domains

Agricultural potential reflects a number of different underlying factors, including rainfall, soil type and quality, altitude, slope, topography and presence of pests and diseases. Market access is also critical for determining the comparative advantage of a specific locality for producing a specific commodity. Market access is a multi-dimensional factor encompassing distance and travel time and hinges on the concept of transaction

costs. Population pressure has long been acknowledged as a major driving force with respect to the labour intensity of agriculture, creating a conducive environment for innovations in technology, institutions, markets and infrastructure.

Methodology

To get a handle on the classification of situations in the highlands of Ethiopia, a more statistically robust methodology is needed. The methodology proposed in this paper uses a community level survey of 100 villages in the case study area. The goal of the exercise is to classify each village (*kushet*) into a three dimensional matrix of factors influencing development potential. In addition, an analysis of livelihood strategies derived from the same survey will give an indication of the development opportunities in each category.

For each dimension there are usually a number of different variables related to it. To choose a useful proxy variable is thus not always easy. By using principal component analysis to reduce the data, single quantitative measures are derived for each main factor. This has the advantage of using all the variables in the data set that are relevant while preventing to a large extent the occurrence of dependency amongst the development domain dimensions.

Because we are not able *a priori* to determine if the development domain dimensions are completely independent, we test for this independence using two-stage least squares and seemingly unrelated regression. Once we have quantified the development dimensions, a rough analysis on the variables related to livelihood strategies and development opportunities can be done. This analysis consists of regressing the development domain dimensions on those variables. Again the choice of variable is very important. Factor analysis was used to reduce the number of variables taken from the community survey. The data reduction is done in five spheres. Three are related to agricultural production: cropping systems, livestock activities and technology choice. One is related to credit use and one is related to development indicators. If development domains are important in determining development pathways then these variables that are an outcome of the current development pathways of the communities in Tigray should depend to some degree on the development domain dimensions.

Results

The results of testing of linkages between the development domain dimensions indicate that they are almost completely independent. The main cereal cropping systems distinction in terms of three combined variables accounting for 42% of the variance in the data is explained to a large extent by the development domain dimensions. The most important dimensions are related to agro-climatic conditions (rainfall and altitude), and to a lesser extent market access and population density. Minor cash crops depend on market access.

The analysis reproduces the different livestock strategies linked to different agro-climatic zones. The system with cows and beehives that is linked to households with no oxen belongs to densely populated areas with poor soils and poor market access and lower altitudes.

Four technology sets stand out in the analyses. Erosion management, high cost input use, soil bunds, improved seed and vaccinations are all explained between 12 and 24% by the development domain dimensions. These technology sets occur on good soils or soils that are not too degraded.

The use of credit is an endogenous variable of household livelihood strategies. It can be linked to development domain dimensions and to institutional dimensions. The same holds true for development indicators. Twenty five percent of the variation in the health indicator is explained by the development domain dimensions, especially institutional factors.

Policy implications

The analysis using a quantified methodology for determining development domain dimensions and linking this to data concerning livelihood strategies produces important insights for policy makers. Besides reproducing common knowledge that serves as a check on the methodology itself, it provides insight into the different ways predominant livelihood strategies depend on development domain dimensions.

The predominant cropping systems do not depend on soil quality or level of degradation. The most important dimensions that play a role are rainfall and altitude (temperature) that are the determinants of suitability of a certain agro-ecological zone for a certain crop. In some cases crop choice depend on factors like population density and market access. Maize is found in more densely populated areas where otherwise sorghum would prevail. Better market access in the low altitude areas seems to favour millet production. Market access is very important in the adoption of minor cash crops.

Livestock systems show a different picture. Here poor soil quality is linked to production activities that generate secondary livestock products (dairy products and honey) that can be sold. This does not require good market access implying that policy interventions aimed at different development domains should be different. Areas with good market access can benefit from minor cash crops. This implies that to promote these crops, infrastructure development is a prerequisite.

Technology choice hinges heavily on soil quality and level of land degradation. The use of improved seeds depends on market access. The use of external inputs in general depends on population density. This implies that farmers are more willing to intensify in high population areas, especially if soil degradation is not yet a huge problem. In general, improved technology adoption is positively correlated with better soils or less degraded soils. The policy implication that arises from this conclusion is that land rehabilitation is not something that will occur regardless of interventions. It makes sense to use public interventions to rehabilitate the land. On the rehabilitated land, farm households will

then be more capable and willing to do necessary investments to improve production and productivity.

There is a strong link between credit availability and use. Formal credit from development agencies tends to coincide with less degraded areas. Since there is no policy to provide credit especially to the better-endowed areas, it can be concluded that credit demand is higher in better-endowed areas. Again, because credit is instrumental in improving production and productivity, it can be concluded that land rehabilitation is a public good.

The results in this paper are promising. Using community level surveys and asking general questions that are an indication of the predominance of development pathways in terms of the livelihood strategies of community members, it is possible to extract tendencies that are linked to specific development domains. While the methodology in itself is robust, further research can be used to fine tune the outcomes, to develop further policy recommendations. The outcomes of this stratification can also be used for developing bio-economic models and as an additional input into econometric analysis of household survey data.

Comments *by Samuel Benin*

I was supposed to discuss the papers by Wood et al. and Kruseman et al. However, as only the paper by Kruseman et al. was ready, my comments are directed at this paper only, which was very relevant and well written.

Development domains are important in policy considerations for sustainable development and offer scope for targeting interventions. This is because of the complex situations that exist in different places, such that a one-size-fits-all approach everywhere is inappropriate. Development domains in this paper were defined based on agricultural potential, market access and population density, three factors considered to be important in different development strategies. The authors used factor analysis to identify and quantify the key variables, since there are many potential variables for each domain. For example, precipitation, elevation, soil quality and level of erosion were used to define agricultural potential; and physical distance to nearest infrastructure (road and market) and presence of institutions (co-operatives and government agencies) that facilitate market participation were used to define market access. The authors then examine the importance of these domains as determinants of livelihood strategies, technology choice and resource management. Some interesting results were obtained, suggesting that development domains are important in many cases in shaping development strategies.

In general, rainfall seems to be the most important factor (as it was significant in most of the regressions), compared to both the other dimensions of agricultural potential and the other development domains (market access and population density). It seems that market access is important in mainly determining livelihood strategies, while population density is equally important in determining technology choice, resource management and livelihood strategies.

The paper, however, failed to analyse the data further to try to explain some of the puzzling results. For example, the relevant policy/programme variables (e.g. presence of co-operatives, provision of credit by the Bureau of Agriculture) were negatively associated with some of the technology choice indicators (e.g. erosion management and tree planting, contour plowing).

Livelihood strategies and land management practices in the highlands of Tigray, northern Ethiopia

J. Pender,[a] *Berhanu Gebremedhin*[b] *and Mitiku Haile*[c]

a. International Food Policy Research Institute (IFPRI), USA
b. International Livestock Research Institute (ILRI), Ethiopia
c. Mekelle University, Ethiopia

This paper investigates the livelihood strategies and land management practices used in the highlands of Tigray Region, the factors influencing them, and their implications for crop production and income, livestock income and investment, other sources of income, and farmers' perceptions of land degradation. Several factors commonly hypothesised to have a major impact on land management, incomes and land degradation—including population pressure, small landholdings, access to roads and irrigation and extension and credit programmes—are found to have limited direct impact on total crop production and incomes.

However, some of these factors have a substantial impact on livelihood strategies (e.g. population pressure and access to roads and transportation) and, thus, can have a significant indirect effect on incomes via their impacts on livelihoods. The net effect of these indirect impacts is difficult to determine, however, since some of the livelihoods promoted by population pressure or improved access to services earn relatively low incomes while others earn high incomes. As population continues to grow and access to roads and transportation improves, increasing inequality of income may thus occur as a result of livelihood diversification.

Most of these factors affect the intensity of agricultural production and adoption of various land management practices. Population pressure and/or smaller landholdings are associated with greater use of labour and other inputs and adoption of labour-intensive practices, as predicted by Boserup. Access to an all-weather road increases use of labour and fertiliser, while irrigation increases use of labour and improved seeds, as one would expect. Formal credit is surprisingly not associated with use of improved seeds and fertiliser. However, these impacts on intensity do not add up to much impact on total crop production, due to the low marginal product of labour in crop production, the limited productivity impact of inputs such as fertiliser and seed in the moisture-stressed environment of Tigray and limited adoption of such inputs.

Some land management practices were found to substantially increase crop productivity, including construction of stone terraces, reduced burning, reduced tillage and application of manure or compost. The rate of return to investment in stone terraces was estimated to be about 25%, and terraces were found to increase use of fertiliser. Reduced burning, reduced tillage and application of manure and compost have even larger estimated impacts on productivity. These practices apparently contribute to productivity

by helping conserve soil moisture and organic matter, which are critical constraints in the soils of Tigray. Manure and compost are also found to contribute to perceived improvement in soil fertility. Greater ownership of cattle is also strongly associated with increased crop productivity, probably as a result of increased manure availability (whether or not intentionally applied). Promotion of such conservation practices and exploitation of complementary livestock production show more promise to boost crop production than large application of modern inputs such as inorganic fertiliser and improved seeds. However, there are opportunities to exploit complementarities between use of such inputs (especially fertiliser) and investment in stone terraces.

Improved livestock production can contribute to significantly higher household income, both directly through income earned from livestock, and by contributing to increased crop production. The marginal net rate of return of livestock in terms of livestock income was estimated to be about 11%, but was significantly higher for cattle, chickens and beekeeping. Considering the impacts on crop production as well as livestock income, the gross rate of return in 1998/99 was about 16% for all livestock and 36% for cows. The rates of return to chickens and beehives were also above 30%. Thus, there appear to be promising opportunities to increase household income through improved livestock management. This is supported by the fact that households whose livelihoods are cereals–livestock or cereals–beekeeping earned substantially higher returns from livestock than other households, controlling for the value of stock owned and other factors. Members of agricultural cadres and households who have participated in a literacy campaign also earn substantially higher livestock incomes than other households. These types of households have greater skills in attaining high returns from livestock than other households. It could be valuable to study further how such farmers are able to achieve higher returns, and to incorporate lessons learned into the agricultural extension programme and development projects.

Improved literacy contributes to significantly higher per capita incomes, largely through the positive impact on livestock productivity mentioned above. Another factor strongly associated with higher household incomes is membership in a marketing co-operative, predicted to increase household income by more than Ethiopian Birr (ETB)[1] 1000, mostly through higher value of crop production. How such organisations are able to boost incomes substantially should be studied in detail, and lessons drawn about how and where such beneficial impacts can be replicated.

Households pursuing livelihood strategies by generating non-farm income, such as off-farm salary employment, trading and food for work, earn substantially higher total income than households specialising in crop production. Promotion of such non-farm activities, through development of roads, vocational training and other programmes, could thus help to boost incomes in the Tigray Region. Surprisingly, formal education was not found to be associated with greater adoption of non-farm activities, though this may be due to limitations in the data (limited number of formally educated households in the data). Further study of this issue is needed.

1. In 2002, US$ 1 = ETB 8.50.

Households that depend on food aid or other assistance as a secondary source of income have significantly higher total and per capita incomes (not counting the value of assistance received) on average than households reliant solely on cereal crop production. This suggests possible lack of targeting of food or other aid to the poorest households. Given the relatively small number of aid dependent households in our sample, this result could be a statistical anomaly (though the result was statistically significant with 95% confidence). Further study of the targeting of food aid and other assistance appears to be warranted.

Two categories of households that face greater poverty than others are female-headed households and larger households. Female-headed households earn substantially lower crop income and total income than male-headed households. While larger households earn comparable or larger total household income than other households, their income per capita is significantly lower. Increased efforts to address these problems through improved education of girls and women, family planning and other targeted interventions appear to be needed. The fact that households with members of a women's association earn substantially higher non-farm income suggests that such associations can help by promoting income diversification.

Land tenure was not found to be a major factor affecting total crop production and household income. However, the evidence show that tenants (mainly sharecroppers) use fewer inputs and obtain lower yields at the plot level than owner-operators. This may be because restrictions on the duration of land lease contracts (no more than two years unless the tenant uses 'modern technologies') prevent landowners from leasing land to tenants that they know well, so that the incentive problems involved in sharecropping (i.e. tenants' incentive to use less inputs because they receive only a fraction of the resulting output) can lead to reduced farming intensity and yields. This problem was not observed in several villages in the Oromiya region, where the average duration of sharecropping arrangements was much longer than two years. Thus, the restrictions on land leasing in Tigray may be inhibiting productivity on sharecropped land. The regional government should consider whether such restrictions are necessary and helpful, or perhaps lengthen the allowable duration of tenancy contracts regardless of the technology used.

Overall, the findings of this study show that profitable opportunities exist to increase agricultural production, household incomes and achieve more sustainable land management in the highlands of Tigray. These opportunities include improvement of crop production using low-external input investments and practices such as terraces, manuring, reduced tillage and reduced burning; improved livestock management; and diversification of livelihoods towards non-farm activities and small-scale livestock such as poultry and beekeeping. The comparative advantage of people in the Tigray highlands is not in intensive cereal crop production but more in such alternative activities. As a result, greater emphasis on developing these alternatives in agricultural extension and other development programmes may be fruitful. Food crop production should not be ignored in the development strategy, but less promotion of purchased inputs such as fertiliser and improved seed and greater emphasis on non-farm opportunities, livestock and sustainable land management practices may be helpful.

Comments *by Frank Place*

The paper is based on a very large and rich dataset, and the authors try alternative specifications and analyses to understand the impacts of individual variables. They also pay attention to the nature of the dependent variable and the implications for statistical model type. The motivation for the independent variables is well conceived with a framework. However, the paper is too long and there are too many analyses reported. I counted 54 regressions and it was difficult to remember results. For a book chapter or other written forms, there is a need to reduce the length, either by dropping entire portions or prioritising what to emphasise.

Despite the large number of explanatory variables, care is taken in interpretation of results. However, there are a few places where the explanation provided is based on another included variable. One case is that 'female adoption of manure is linked to labour and livestock holdings', but the latter two are included. Another is households having members of a women's association use less oxen power or seeds; perhaps because these households tend to rely more on income from other sources besides crop income. Maybe the authors had confirmed these relationships and were just acknowledging that there could be another factor, but it was not clear from the writing.

Some explanations are noted as 'possible' when I believe that the data exist to test them rather than leaving things ambiguous. An example is 'probably mix of crops includes higher value crops closer to town'. Another is the suggestion that informal land markets function reasonably well to enable landless households to obtain access to land for farming.

There are many unexpected results and several may be related to links among the explanatory variables and, thus, capturing partial direct effects only. Others may well be true and since some could run counter to mainstream thoughts, it will be good to demonstrate further why they are observed. Otherwise, people may think that the research was not done properly. Some results appear contradictory (not many). For example, the use of fertiliser was higher in lower rainfall areas but later it is stated that use of fertiliser is unprofitable and risky in semi-arid environments. If both are true, then more explanation needs to be provided as to why fertiliser is being targeted in such areas or on why it is used by farmers in those areas.

There are some policy implications provided for the types of promising enterprises and investments for Tigray. A next set of questions might be to figure out which types of households might be best able to adopt these best bets. Who is left out? How can one reach the poor? By looking across the results, much more could also be said about policies needed to reach women, the poor, the less educated and so on. An example is that non-farm strategies seem to be used by female-headed households, the less educated, and do not require access to roads. The specific types of non-farm strategies that are most promising could also be highlighted along with a couple of options for moving them forward.

Development pathways and land management in Uganda

E. Nkonya,[a] J. Pender,[a] D. Sserunkuuma[b] and P. Jagger[a]

a. International Food Policy Research Institute (IFPRI), USA
b. Makerere University, Uganda

The major objective of this study is to analyse the development patterns and land management practices in Uganda, their causes and implications, based on household and plot level data collected from 451 randomly selected households in southern, central, eastern and parts of northern Uganda.

This study has demonstrated that different livelihood strategies and land management practices are pursued in different parts of Uganda, and that these are substantially affected by differences in agricultural potential, market access, population pressure and other factors. Agricultural commercialisation and urban development are increasing in Uganda in the wake of structural adjustment and market liberalisation policies. This is increasing farmers' income earning opportunities both on and off the farm, but is also contributing to soil nutrient depletion, as exported plant nutrients are not being adequately replenished. Use of inorganic fertiliser is very low, and organic practices such as manuring, composting, mulching and use of leguminous crops for biological nitrogen fixation are still relatively limited.

The study investigated numerous factors influencing households' choice of livelihood strategies and use of land management practices, including agro-climatic conditions, access to markets and roads, population pressure, households' endowments of land, labour and other forms of capital, access to technical assistance and credit programmes, land tenure and others. It was found that technical assistance programmes are having substantial impact on increasing adoption of improved land management practices, yields and income of some crops (e.g. bananas), livestock incomes, incomes from other farm and non-farm activities and reducing soil erosion. This broad set of positive outcomes suggests that 'win-win-win' strategies contributing to increased agricultural productivity, reduced poverty and sustainable use of natural resources are possible. Still, the coverage of these programmes is very limited, and the vast majority of farmers have not been involved in extension or training programmes, especially in remote areas such as much of the eastern highlands.

Adoption of fertiliser was found to be associated with much higher yields of maize and coffee, though the sample size was very small, limiting our ability to draw general conclusions about the impacts of fertiliser use. Inorganic fertiliser was applied mainly to maize, especially in the eastern highlands. Many of the organic practices, such as application of manure, mulch and incorporation of crop and household residues were found to have insignificant or mixed impacts on crop yields, in some cases being associated with lower yields. This may be because the impacts of such technologies depend importantly on how they are applied; for example, inadequate storage and application of

manure can limit its effectiveness. Also, soil organic matter appears no longer to be the most important indicator of soil fertility, and is still adequate in many locations. Thus, more targeted approaches to addressing soil fertility problems are needed.

The research found low oxen use and farm mechanisation, especially in the high and low bimodal rainfall zones and the south-western highlands. Insurgency of rebels and cattle rustling may have affected use of oxen in the north, north-eastern and eastern zones. However, it is surprising that even in areas with a large number of cattle, like the bimodal low rainfall zone in the southwest, use of animal power is limited.

About 85% of households reported to own bicycles, which are important for transportation. However, bicycle payload is low and the estimated agricultural marketed surplus is only 20%. Ox-carts and other means of transport could help to stimulate agricultural marketing. Over three-quarters of households reported owning radios. Radios may therefore be used to disseminate production technology and market information in rural areas.

Better market access was found to contribute to some intensification of inputs, such as fertiliser, though this is still very limited. Better market access was also associated with higher yields and incomes from bananas, but lower yields of maize, perhaps as a result of land degradation. Efforts to intensify soil fertility management, especially in commercially oriented crop production in areas of good market access, are critically needed. Better market access also is associated with some livestock activities, such as pig production, while other livestock activities, such as extensive cattle ranching, are more important further from markets.

Population growth and small farm sizes are serious concerns, especially in the densely populated areas of the highlands and the Lake Victoria region. We find evidence that small farmers adopt more intensive methods, as predicted by Boserup, but yields of several crops are lower on these small farms. Thus, intensification does not appear to be overcoming the negative impacts that population pressure and small farm sizes is having on yields and incomes. Our evidence also indicates that perceived erosion problems are greater on smaller farms, and that some of the intensive practices used by smaller farms appear to increase erosion problems. Thus, our findings do not support the optimistic 'more people, less erosion' view; and indicate that efforts to control population growth and land fragmentation in Uganda are needed to help stem land degradation and declining productivity.

The importance of maize and bean production is increasing in almost all zones of Uganda. This increase may be due to a livelihood strategy that seeks to diversify household income and/or a response to changing food habits and emerging markets. The implication of the spread of cereals and pulses on soil fertility is not clear. However, if cereals and pulses are replacing perennial crops, which are associated with better soil cover and soil conservation and less tillage, then land degradation may be accelerated.

Investments in livestock offer opportunities for substantial economic returns and income diversification. However, the average livestock contribution to farm household income was only 5%. The high market access areas reported the highest adoption of improved dairy cows, while less densely populated areas reported higher number of cattle heads. Very limited livestock extension and veterinary services were observed. This

points to the need to take deliberate efforts to improve technical assistance for the livestock sector. Marginal rates of return appear to be highest for poultry and pigs (over 100%), though cattle are also relatively profitable. Livestock ownership contributes to intensification of crop production, as well as providing an important source of income. Complementarities between cattle and banana production appear to exist, though the exact nature of the complementarity is not clear. There are problems of soil erosion related to livestock grazing, and these deserve greater attention.

Improvements in education are also helping to increase rural households' opportunities and incomes substantially in Uganda. Education is contributing to improved productivity of some crops and of livestock producers, but, in general, it appears to be promoting increased off-farm activities. As a result, more educated farmers are less prone to adopt intensive practices, and this appears to be contributing to the lack of intensification in Ugandan agriculture.

Other factors such as land tenure and access to credit were found to have mixed or limited impacts. There are mixed associations of land tenure rights and arrangements with land management practices and productivity. In general, we do not find support for the common presumption that freehold tenure is superior to other tenure forms in promoting improved land productivity or sustainability. In many instances, productivity is higher and land degradation is lower on customary or mailo land. We also did not find support for the hypothesis that owner-operated plots are generally more productive than leased-in or borrowed plots. However, this may be due to greater soil mining on leased-in plots. Further study of such issues is warranted. However, the evidence in this study does not suggest a need for rapid conversion of mailo or customary land to freehold status, as envisioned by the 1998 Land Act.

This study observed that the poorest regions are the north and east, pointing to the need to target programmes in these areas to address poverty problems. The impacts of market access and population density on poverty are ambiguous. The larger farm sizes and livestock herds found in the low market access and low population density areas tend to lead to higher incomes in these areas.

Policy implications

In general, the findings show that there are many opportunities to increase farmers' incomes and help ensure food security while improving land management. Different comparative advantages exist in different parts of Uganda, and this should help to guide more targeted technical assistance and public investment strategies. No 'one-size-fits-all' strategy will work throughout Uganda, though successful development will require increased investment in technical assistance, continued investment in education and infrastructure and continued commitment to market liberalisation, development of private markets for agricultural inputs, decentralisation of governance and assurance of peace and security.

Specifically, our observation that areas with high market access were associated with higher agricultural intensification but declining yields of several crops suggests that nutrient depletion in such areas is a major concern. Although improved market access may increase efficiency of agricultural marketing, low profitability of outputs may limit farmers' ability to apply adequate inputs to stop the nutrient depletion. Therefore, large use of external inputs may not be a feasible option for addressing land degradation. One of the solutions often suggested for this problem is integrated soil fertility management, which includes use of a variety of sources of nutrients and cultural practices that conserve, add or increase availability of naturally occurring nutrients. However, organic fertility sources did not show significant increases in most crop yields. This calls for increased research and extension efforts to generate and disseminate organic fertility management technologies that are acceptable to and profitable for smallholder farmers.

Special efforts are also needed to expand coverage of technical assistance programmes to remote areas. The study has shown that non-governmental organisations contribute significantly to provision of extension services, but that their coverage in remote areas is limited. This points to the need to encourage involvement of such programmes in remote areas.

Our observation that high population density is associated with lower yields and soil erosion calls for the need to relieve the land pressure by creating alternative non-land based activities and family planning programmes to complement the agricultural intensification option that the farmers are already taking in densely populated areas. Education may be one of the approaches of relieving land pressure, as education is found to increase the probability of farmers' engagement in off-farm activities. However, education is associated with less adoption of labour-intensive land management practices. There is a need to include practical training in agriculture and land management in educational curricula to minimise negative impacts of education on land management.

The increasing importance of maize and beans in most farming systems, including the banana–coffee system, has not been accompanied by a major increase in fertiliser use or soil conservation measures. It is likely that the introduction of the cereals and pulses may increase land degradation in the banana–coffee system. This suggests the need to have a vigorous campaign of better fertility management and soil conservation for annual crops in order to stem the potential increase in land degradation.

Livestock extension services need to be increased to allow farmers to take advantage of the economic potential of livestock in rural areas. Opportunities for improved incomes from dairy cattle, pigs and poultry appear to be quite high, especially in higher market access areas. For this to be effective, it needs to be accompanied by facilitation and improvement of livestock product marketing and processing. These efforts are likely to increase the value of animals and their products, which in turn would increase the present low contribution of livestock to family income.

Use of animals for farm mechanisation is also quite limited, perhaps because of lack of awareness and exposure of the benefits of using animals for transportation and farm operations. A need to encourage and sensitise farmers to use animal power for transportation and plowing is apparent. To support this effort, village artisans may be trained to

make simple and cheap animal-drawn carts and plow sets that are affordable and easy to maintain.

The high proportion of radio ownership offers a chance of using them to disseminate extension messages and agricultural market information. To increase their effectiveness, local content and use of local language in the radio programmes are critical. The programmes also need to be broadcast at times that are convenient to farmers.

Comments *by Frank Place*

As with the other paper on Ethiopia, there is a lot of good analysis and the big issue is in reducing the volume to a chapter or article size.

I have a concern about freehold tenure and this also came up during the conference. What does this refer to? In practice, there was hardly any freehold tenure at all, limited to a few (three, I think) pilot registration schemes and then to a few other large commercial farmers. I think that some other freeholds emerged in peri-urban areas, but I am surprised that there are such high percentages. I wonder if it is truly 'freehold' or just responses by farmers that it is individual or private land? The fact that hardly anyone mentions a title would support the argument that it is not really freehold. This is important to clarify since it crops up in the conclusions. Related to this, it is possible to find some negative consequences of bonafide freehold land if it is reflecting the land controlled by the elite near Kampala (who are not really interested in farming but rather in speculation or to use as collateral for credit). There was a later speculation about community enforcement of by-laws on customary land versus freehold land that also should be re-examined in this context.

Related to this, there was some mention about coffee and banana yields on borrowed plots. I am surprised to hear of coffee being on borrowed plots. Are these what they call caretaker situations whereby a brother or other relative is tending the land of a relative for a period of time, often when the latter is away?

Some of the results reported also seem unusual (e.g. higher income in less favourable areas). I can only suggest rechecking the data to see if there might be patterns of measurement error with certain enterprises or income sources that vary across different ecological zones. However, it could be less surprising to see some equalisation of incomes across zones because my impression is that rural–rural migration is much more active in Uganda than Kenya, for example. Another example concerns the reason given for lower small ruminant income in the highlands. In Kenya, goat diseases are rare. It may just be that with more cattle, there is not enough feed for goats as well.

The discussion of many specific development pathways seems too rigid in that communities and farmers alike will often pursue several of them at the same time and a recommendation may well be for a community (or farmer) to pursue several at the same time. There is mention that *matooke* will have potential near urban centres, but this is counter to the reality in that much comes from Mbarara, Rukungiri and Bushenyi that are not close to Kampala. I am also not sure that dairy products can be produced in

extensive low potential areas—there is a need to have high quality feeds to have high milk yields and those are usually found in the higher potential areas.

Tree production is touted for high rainfall and low population areas. But note also that trees should be good in lower rainfall areas where they have advantages in acquiring moisture over annual crops. It is also mentioned that fuelwood must be produced close to markets, but in reality firewood to towns has also been coming from far away places. Often, wood is more valuable sold as firewood than sold as poles.

The authors make a link between replanting coffee and increasing importance of coffee. That is not clear because replanting suggests that the importance remains the same. In adoption of animal breeds it is noted that *ankole* longhorns could be the reason for high numbers of improved local breeds in the south-western highlands. I don't recall seeing any in the real highland areas, only in Mbarara. There could be some, but this could be checked.

These may not have surfaced much in the data, but there are some enterprises that are locally very important that are not discussed. This includes tomatoes and other vegetables that are important in many areas, tea that is very important in some areas of the southwest, and Irish potatoes that the International Centre for Potatoes (CIP) found is the most important income source for farmers in Kabale and Rukungiri.

I wonder why crop residue incorporation enhances erosion. Normally, the residues are cut and taken away otherwise. Maybe it is specific to certain types of crops? Why manure has negative impacts on coffee and maybe maize is puzzling because certainly farmers know how to manage manure and would not do it without benefiting. Are there omitted variables? The explanation that livestock income may allow expansion of banana I think probably does not hold. My understanding is that banana expanded into Mbarara and nearby places when diseases decimated its productivity near Kampala. It so happens that there are large herds of *ankole* cattle in Mbarara, but I think these are not the same households.

Development pathways in medium-high potential Kenya: A meso-level analysis of agricultural patterns and determinants

F. Place,[a] R. Kruska,[b] T. deWolff,[b] P. Kristjanson,[b] S. Staal,[b] R. Zomer[a] and E. Njuguna[c]

a. International Centre for Research in Agroforestry (ICRAF), Kenya
b. International Livestock Research Institute (ILRI), Kenya
c. Department of Resource Surveys and Remote Sensing, Kenya

Background and objectives

The highlands of East Africa are endowed with a combination of moderate temperatures, adequate rainfall (falling in two distinct seasons for much of the highlands) and productive soils that make the region one of the best suited for agricultural development in all of Africa. The good news is that, in some areas in the highlands, it is clear that land use change has been part of a productive and sustainable pattern of agricultural development. The bad news is that the trend in the majority of the highlands appears to be a downward spiral of increasing population pressure and land degradation, declining agricultural production and entrenched poverty. Over 50% of the rural population in Western Kenya lies below the poverty line. The key development challenge the paper addresses is how can successful intensification cases be replicated or adapted in the wider highlands to overcome widespread poverty and land degradation in a manner that leads to sustainable improvement in livelihoods? What are successful land uses/management strategies, and are they feasible only in certain physical and climatic environments, or can they be catalysed in diverse areas given proper market development?

Methodology and data sources

We test the following relationships:

1. Land use = f (conditioning factors)
2. Land use = f (conditioning factors, driving forces)

where conditioning factors are related to climatic and physical characteristics that are fixed. Driving forces include market access and population pressure, which can be changed by policy. The resolution of equations (1) and (2) can provide some insights as to what types of land uses are achievable under various conditions, and, to some extent, how such systems can be promoted. However, they do not provide evidence as to why

certain land uses should be promoted over others. Thus, we also need to examine the following equations:

3a. Poverty = f (conditioning factors, driving forces)
3b. Poverty = f (conditioning factors, driving forces, land use)

The data used in the analysis reflect different spatial units and are drawn from different sources. Many of the variables, including the land use variables, are generated from aerial photos of 45 hectare-sized areas. Available data on physical and climatic conditioning factors are altitude, slope, rainfall, length of growing season, temperature and the precipitation to potential evapotranspiration ratio. There are potentially many important driving forces behind land use decisions. However, the data set used includes population density and various measures of market access only. The latter is measured by travel time to urban centres.

Land use variables were generated from 5546 photos taken in 1997 from 30 districts. A total of 97 land use or cover variables could potentially be distinguished and these include not only different crops, but also non-agricultural land covers including water bodies, roads and man-made structures. In our analyses, we focus mainly on explaining differences in maize, cash crops/horticultural production and woodlots, as other land types were neither common nor sizeable. We also attempt to explain the current intensity of cattle and dairy cattle raising.

For poverty, we used the proportion of roofs that were of high value (tile or tin) as opposed to thatch. While there are certain cultural preferences as to roof type, this variable is widely considered to be associated with more robust poverty measures. As for natural resource management, the percentage of land under tree canopy cover is the only useful variable at our disposition for each of the 5546 sites.

Development domains

In order to define distinctive and meaningful development domains, the highlands were partitioned into zones according to agricultural potential, population density and market access. The simplified delineation of development domains assumes only two categories for each of the three variables (high and low), which in combination can yield a maximum of eight distinct outcomes. The highlands near Nairobi, as well as those in the densely populated western highlands, have good access to large concentrations of people. Market access is worse on the northernmost and southernmost reaches of the highlands. Among the low market access areas, almost all have low population density and low agricultural potential. In terms of overall importance, four development domains stand out (all with high market access):

1. High agricultural potential, high population density (7.2 million people)
2. Low agricultural potential, high population density (3.5 million people)
3. High agricultural potential, low population density (2.3 million people)
4. Low agricultural potential, low population density (1.7 million people)

Land use

Non-cultivated land occupies the majority of land area. The largest single category made up of grazing, pasture and fallow land is found in nearly all sites and has a mean percentage area of 45.2%. Bare or bush land occupies 13.4% of land, wooded land (woodlots, plantations, forests and woodlands) another 7.5%,[1] and other non-cultivated area 3.9%. As for crops, this analysis shows the predominance of maize and maize intercrops in the areas covered. Eighteen percent of the landscape was devoted to maize and the crop was found in nearly 76% of sampled sites. Maize comprises 75% or more of cultivated area in 60% of the sites. Traditional industrial crops of coffee, tea, sugarcane and cotton occupy around 8% of total land area. However, these crops are found in only about 36% of the sites. Other crops are of only minor importance at the landscape scale.[2] The mean tree canopy (spanning both agricultural and non-agricultural land) across all sites was 15.8%.

Data for cattle and dairy density (at divisional level) indicate that the mean number of cattle is 101/km^2 with a median of 72. Almost every site for which data are available reports the existence of cattle. The average dairy cow density is 39/km^2 and the median is 20. There are pockets of high dairy cattle density — 17% of sites report dairy cow density of over 75/km^2.

Factors behind agricultural enterprise choice

Due to a restricted number of available explanatory variables, we do not develop causal models, but rather models of association or prediction. In terms of total area under maize or cash crops (industrial and horticultural crops), all included variables are statistically significant and they are of the same sign in both cases. The results show that maize and cash crop area increases with improved climate and market access, and follows a positive curvilinear path with respect to altitude and population density. Hence, the influence of better climate, denser population and better access to markets is to increase crop area relative to non-crop area (e.g. grazing area).

Some interesting results arise from the models where maize and cash crop area as a percentage of all cultivated area are the dependent variables. Favourable climate and market access tend to reduce farmers' reliance on maize. Market forces in particular tend to be associated with higher value crops. Interestingly, while population pressure leads to expansion of cropped area, it does not directly influence the balance between maize and cash crop cultivation. The impact of improved market access is three times as high in relatively favourable areas than in less favourable areas.

1. Planted woodlots (by farmers) were identified in 37.5% of sites and the mean size across all sites was 2.1% of land cover (only a portion, therefore, of total wooded area).
2. These figures match fairly well with other available farm-level surveys, except for napier grass, which has been found to be quite prominent in many districts yet almost absent in the aerial photo interpretation.

The factors influencing overall cattle density as well as the density of dairy cattle is almost identical to that with cash crops, including a strong influence of market access, especially on dairy cattle. Mirroring the results for cash crops and cattle, woodlots are promoted by favourable climate and improved market access and tend to increase, but only to a certain level, as population density and altitude increase.

Impacts of agricultural enterprise choice

A natural reaction to the analysis above may be to ask why any particular agricultural enterprise might be preferred over another? In other words, is there any evidence that certain agricultural enterprises are more productive, profitable, or take better care of the natural resource base than others? The one proxy variable calculated from the aerial photos relevant to profits or poverty was the percentage of roofs made of high quality material (i.e. tin or tiles).

First, this wealth indicator is related in much the same way to the conditioning factors and driving forces, as were the agricultural enterprises. Cash crops, dairy cattle and woodlots each had a measurable and positive impact on high quality roofs. While it is not possible to state unequivocally that these land uses promote wealth accumulation, this finding strongly suggests that such enterprises are important ingredients in wealth generating processes.

A final analysis looked at the impact of land use on the percentage of tree cover across the entire landscape (i.e. the entire 45-hectare photograph). As expected, the percentage area under cultivation has a strong negative impact on the percentage tree cover (with or without population density controlled for). Interestingly, if the percentage of cultivated area under cash crops is substituted for the maize variable, we find that it is positively correlated with tree cover. Whether this is primarily due to effects within agricultural land or to pressures on resources outside of agricultural land is not clear.

Conclusions

The major empirical findings can be summarised as follows:

- as expected, climate is key in explaining land use, but other factors also play important roles
- population pressure alone positively influences the area under cultivation but does not automatically lead to adoption of higher value crops
- good market access is critical for promoting production of higher value agricultural enterprises, especially in the more favourable climate zones
- cash crops (including horticulture), dairy and woodlots all contribute to wealth generation, as measured by house quality.

The analysis was not able to address the important non-agricultural sector. A second limitation is the use of single equation models that ultimately show patterns of association

rather than causal relationships. A third limitation is the existence of spatial auto-correlation in the dataset without sufficient treatment in the statistical analysis. However, spatial econometrics for limited-dependent variables is a developing field of research, and no satisfactory methods are yet available for addressing spatial auto-correlation in logit models. The promotion of markets, through investment in roads and other infrastructure is an obvious implication of our results. This broad-based intervention is a good strategy because evidence shows that farmers like to diversify among many agricultural enterprises, including food, feed and cash crops. There is still scope for promoting markets for longstanding and new cash crops and for disseminating information about their management. In the less favourable areas, there is the additional need to identify and develop higher value enterprises suitable to these areas (in addition to cattle raising, which is already practised by households), because road development does not seem to have the same strong impact with the currently available cash crops as it does in the higher potential zones. Finally, given our results regarding the positive influence cash crops, dairy cattle and woodlots have on wealth, the predominant role of maize in smallholder agriculture should be seriously challenged within Kenya's Poverty Reduction and Rural Development strategies, and support to these other options pursued.

Comments *by Berhanu Gebremedhin*

This paper is a report of a work that is pretty much in progress. The paper starts out by posing the important question of how to replicate the few success stories of sustainable and productive patterns of agricultural development into the wider areas of the East African highlands. As such, the paper sets out to address an important and fundamental research question. However, the paper seems to have some technical problems: 1) modelling land uses as independent decisions may not be correct, as for example, a piece of land used for maize will not be used for woodlots. Therefore, the different land use decisions should be modelled together as a multinomial logit regression; 2) econometric problems such as endogeneity and multicollinearity need to be checked; 3) the definitions of some of the dependent variables such as land degradation and poverty may need to be carefully reconsidered since the definitions given in the paper do not seem to be comprehensive enough.

Land degradation, investment, information and incentives in Kenya's Lake Victoria basin

B. Swallow and J. Wangila

International Centre for Research in Agroforestry (ICRAF), Kenya

Introduction and background

This paper is part of a study on 'Improved land management in the Lake Victoria basin' being implemented jointly by the International Centre for Research in Agroforestry (ICRAF) and the Kenya Ministry of Agriculture and Rural Development within the National Agriculture and Livestock Extension Programme (NALEP). The objectives of the study are: 1) to characterise the regional problem setting of poverty, hunger, investment and resource degradation; 2) to apply and test alternative models for understanding farmer investment in land improvement; and 3) to draw implications for research, extension and policy.

Lake Victoria is the second largest fresh water lake in the world and a source of over US$ 100 million annual income from fisheries. The Lake Victoria basin is inhabited by a mixture of ethnic groups, and is characterised by high levels of poverty, declining agricultural production and land degradation (including deficiency in plant available phosphorus), high incidence of HIV/AIDS, malaria and tuberculosis and low labour and land productivity.

Livelihoods, expenditures, food consumption, farming systems and soil management on farm in the western highlands vary considerably by wealth group and/or resource endowment. Previous studies showed that about 47% of poor households worked on other people's farms; none of the poor households hired labour, their farm sizes fall within the range 0.3 to 0.4 ha, and only 37% of them owned cattle. One-half of the low resource endowed households and one-fourth of the medium resource endowed households used crop residues for fuel. Simulated soil N and P deficits were also most acute in the low resource endowed households, and poorer households in Vihiga District tended to farm poorer quality soils and lack the means to invest to improve that soil.

Household investment behaviour, hypotheses and methods

Household investment behaviour in the Lake Victoria basin is intricate, and is influenced by many inter-linked factors. In our study we follow three approaches: 1) the poverty trap

model or self-reinforcing cycles of poverty and degradation; 2) the sustainable livelihood framework; and 3) the 5-Ins model of land investment (investments, incentives, information, infrastructure and institutions), which is based on the premise that natural resource management practices are investments by African farmers.

The probability that a household undertakes an investment in land management depends upon the following factors: level of fixed costs associated with the investment; availability of complementary physical assets on the farm; availability of reliable information about the investment; institutions that support households to access complementary inputs or organise collective inputs; incentives (prices, markets, severity of degradation, profitability, agro-ecological suitability and riskiness of crops); and infrastructure (access to inputs, outputs and extension advice).

Data used in the study were collected in a survey of 522 households conducted in 2001 in 9 locations in the Nyando River basin primarily to establish a baseline of household data that can be later used to assess the impacts of the National Agricultural and Livestock Extension Programme (NALEP) that ICRAF helps to implement in Western Kenya. Probit and tobit analyses were used to estimate models of the factors affecting the probability that a household will undertake relatively short- and long-term investments, respectively.

Results

Children head 6.4% of the households in the Luo areas, while single female-headed are only found in the Nandi areas. Females (widows) head 25, 15 and 8% of the households in Luo, Kipsigis and Nandi areas, respectively. About 35% of the households used inorganic fertiliser, 10% used green manure, 46% used animal manure and 30% practised crop rotation. The average number of soil conservation structures per farm was 1.5; the average number of water harvesting structures per farm was 0.96 and the average number of trees per farm was 505.

One of the most striking results of the study was that variables normally considered to be important determinants of technology adoption (e.g. gender of household head, wealth, household size, farm size and number of organisations the household belongs to) proved to be unimportant when incorporated into a model of long-term investments that includes more specific information and incentive variables. Farmers derive information for innovation from multiple sources. Local information on soil fertility had a positive impact on the number of soil conservation structures, while external information on soil fertility had a negative impact. Rating of soil conservation knowledge had a positive relation with the number of soil conservation structures but a negative one with the number of water harvesting techniques. Rating of water harvesting knowledge had a positive impact on number of water harvesting techniques.

Long-term investments have significant effects on short-term investments. More food secure households were more likely to use inorganic fertilisers, while more fuelwood secure households were more likely to use inorganic fertiliser and practice crop rotation.

Household size significantly and positively affected inorganic fertiliser use. Number of oxen owned had positive effects on the probability of animal manure use and the practice of crop rotation. Total landholding had a positive effect on the number of trees on the farm. In the long-term, fuelwood insecurity was the only significant incentive, with a negative effect on the number of soil conservation structures on farm.

Male-headed polygamous households were less likely to use inorganic fertiliser and had fewer soil conservation structures on the farm. Being a Luo or Kipsigis had a positive impact on the number of trees on the farm, but only being a Kipsigis had a positive effect on the number of soil conservation structures on the farm.

Research, extention policy implications

The results provide good support for the 5-Ins model of investment. The main decision point regarding conservation by the households may relate to whether the household makes the investment or not rather than the intensity of the investment. Long-term investments in soil and water conservation are the outcome of investments made over a considerable number of years and, thus, the current household characteristics may not reflect those characteristics at the time that the investments were made.

Public investments to diversify agricultural enterprises that show promise (such as dairy, woodlots, beekeeping, sweet potatoes, fruit trees) and balance production and marketing are needed in Western Kenya. Public investments should be synergetic to investments by private individuals, community groups and 'sons of the soil', i.e. urban-based landowners who have the capacity to mobilise resources for community conservation projects. Stoppage of conversion of forests and wetlands to agriculture is necessary, but can only be achieved through encouragement of conservation and sustainable use of these resources. Catchment areas previously converted from forest should be given priority for technical and institutional intervention. Extension services should be integrated with public investments in water, health, rural roads and new enterprise development.

Information is very important for land investments. Multiple sources of innovation and information should be encouraged, and creation of greater environmental awareness for all stakeholders is needed. The information exchange and flow should take into consideration special needs of child-headed households and women in polygamous households.

The reform of the fertiliser market should be considered, for example, by creating more options for international sellers, through reduced transaction costs and quality assurance, to better reach farmers and increase fertiliser use. Improving tenure arrangements to protect community interests in springs, community water pans and other community amenities will also enhance investments.

Conclusions

Adoption of inorganic fertilisers is shaped by fundamentally different household factors than adoption of organic fertility technologies. Adoption of land investments depends upon the source, availability and quality of information available to the household. Communities at the forest frontier have in the past undertaken the least investments in soil and water conservation but now are most interested in new opportunities. The Kipsigis, who are in the uplands, are more likely to put soil conservation structures in place.

The Nyando river basin is an area of co-located or co-existent problems of soil degradation, low agricultural production, poverty and hunger. Land investments in this river basin are not subject to poverty traps, limits on assets or gender of household head, however, we should be cautious of extrapolation. Results for short-term investments support the 5-Ins model but results for long-term investments are weak.

Comments *by Isaac Minde*

This is an excellent paper in terms of generating critical micro level information that can help to empirically support relationships observed in the real world. Such information can thus be the basis for community, district and national level policy interventions, as policies are made at all levels of government and institutions. The paper also does some 'groundtruthing' of some indicators that are often found in the literature. For example, the estimation of income through the expenditure data has shown that the income of some rural households is indeed US$ 1 a day. The study also offers a possibility of being replicated in areas where similar circumstances exist.

My comments mostly refer to the model specification and estimation and possible steps to ensure that the variables are the ones that matter most. The following variables are conspicuously missing:

- *Off-farm employment (income)*: This is critical in the adoption of many practices and also in farm investments. Off-farm employment can be of two types; farm, where the person is employed outside his farm household but still on farm jobs, and non-farm, where the person is employed out of his farm but on non-farm jobs like carpentry, service delivery etc.
- *Remittances*: This is a tremendously important source of income for many farm households in eastern Africa. Its importance becomes more prominent as cash earning from crop sales continue to dwindle. For example, I am supporting three households at the moment to buy agricultural inputs—improved seeds and fertilisers. It would be a mistake therefore for a survey not to capture this. In the case of Uganda, it is established that remittances equal or surpass earnings from the first export crop coffee of US$ 500 million. Or is it that the above were taken care of by proxies that I was not able to figure out?

In the results section, it is not sufficient to indicate the percentage of farmers using this and that practice or input. Since we know that the utilisation can be very spotty, it would be useful in addition to indicate the actual amount, be it fertiliser, seed etc. The results as stated are a bit too 'dry'. They basically state the statistical relationship without further explanation, leaving the reader (policy maker or development practitioner) rather puzzled. I suggest that we use the knowledge of the market to support or refute these relationships. At the risk of making the paper longer, I suggest that these relationships be further supported.

A suggestion that could be considered for these types of work as a way of assuring more impact, would be to go back to the research sites and ask the communities 'why they think there is this and that association or relationship or why they think there is not'. This would help to ground truth or validate the results. The following is an example:

Researcher: 'It appears from our analysis that the use of inorganic fertilisers is higher with more food secure households. Do you agree? If yes, why do you think this is the case? If no, why do you think this is not the case?'

Farmer: 'A family that is food secure implies that it has sufficient income and this income can also be used to access inorganic fertilisers.'

This approach would be one of the ways to help reduce the tendency to support spurious association in our work. While the paper brings to bear some very insightful cases and relationships, it lacks clarity on how this wealth of information should/could link up to policy formulation, and the specific processes that need to be followed for their application in the study area. Even if the paper may not have the mandate or time to venture into, at least the 'bridges' should be highlighted.

The implications given at the end remain very academic. Statements like 'extension agents should devise strategies for extending information to specific sub-groups of the rural population, particularly women in polygamous households' could have come from several other studies not even related to this topic of research. An attempt should be made to address the who and how questions. Since this was not an academic study, it has to indicate at least how these excellent findings will help in moving from analysis to dialogue and to action in the policy change cycle. Last but not least, I commend the team for this brilliant study.

Agricultural land management by households in the highlands of Kenya

F. Place,[a] J. Njuki,[b] F. Murithi[c] and F. Mugo[a]

a. International Centre for Research in Agroforestry (ICRAF), Kenya
b. Commonwealth Agricultural Bureau (CAB) International, UK
c. Kenya Agricultural Research Institute (KARI), Kenya

Introduction and objectives

This paper focuses on the management of agricultural land by smallholder households in the highlands of Kenya. This synthesis is primarily meant to understand constraints and opportunities for improving agricultural productivity in a sustained manner. The comparison between the central and western highlands offers considerable insights because one area consists of relatively dynamic and productive agricultural systems (central) while the other is relatively stagnant and unproductive (western).

The reason for focusing on the central and western highlands is that they are similar in terms of rainfall and population density. In both areas, rainfall is ample (mainly between 1400 and 1800 mm) and can accommodate two cropping seasons under normal circumstances. Population density ranges between 350 and 1000 persons per km^2 in most of the central and western highlands. The highland areas lying between the central and western parts are however different, comprising of a disproportionate number of larger commercial farmers.

Household resources and agricultural enterprises

Household resources

Households are mainly independent (in the sense that sons and their wives form their own household and manage their affairs without much influence of the parents) in both the central and western highlands. These independent households are becoming increasingly diverse and complex due to the ravaging effects of HIV/AIDS and the pursuit of alternative livelihood options because of the small farm sizes. Western Kenyan households seem to be more affected, as for many years the number of female-headed households (in which the husband was working off-farm) has been high, around 30% of the population. On the other hand, monogamous male-headed households are the majority in the Central Kenya sites, as shown by recent studies.

In terms of available labour, given the high population densities in the highland areas, there is a large aggregate pool of local labour. But this does not translate directly

into available labour for agriculture. First, many of the individuals are school-going age and have only limited hours during the day to assist on the farm. Second, many of the educated young adults show relatively little interest in agriculture. Furthermore, agricultural wages must compete with other types of employment to attract workers.

The high population densities in both highland areas imply that farm sizes will be small. On average, farms near the slopes of Mt Kenya are of sizes between one and two hectares. Other studies show that while average farm size is about 1.9 ha in the coffee growing zone in most areas of the Western Kenya highlands, average farm size is somewhat lower, ranging between 0.6 and 1.0 ha. Tenure is secure and, in Central Kenya, most farmers hold titles to land. In Western Kenya, many farmers do not bother to update their titles to land that are in the name of their predecessors.

While both land and labour are limiting, most farmers mention lack of cash as the most critical constraint. This stems from lack or irregularity of income, weaknesses in credit markets and high demands for cash, both expected and unexpected.

Current agricultural enterprises

Maize is the predominant crop in the Western Kenya highlands. Other common crops include local beans, bananas, cassava, sweet potatoes and kale/cabbages. The other food crops, including sorghum, tomatoes and groundnuts were found on less than one-half of the farms. Sugarcane was grown by 31% of the households. In Central Kenya, the major crops on farms are maize, beans, potatoes, coffee, macadamia, bananas, tea and passion. A large portion of the area was devoted to traditional cash crops such as coffee and tea (27%) and horticultural crops (19%). On the slopes of Mt Kenya, the proportion of area under coffee was similar (26%) to that of maize monocrop or intercrops (28%).

Although commercialisation does not appear to alter the number of crops grown among smallholder farmers, it indeed appears to increase the level of diversity according to area allocated, by reducing the 'traditional' high allocation of land to cereals and substituting an array of market-oriented crops.

Livestock production in Western Kenya is mainly a semi-intensive dairy–meat–draft–manure farming system, based on local cattle, sheep, goats and poultry. The livestock population is notably small in this region. In the central highlands, however, a majority of households own cattle, as many as 90% in some areas. Of these, nearly all are improved breeds (e.g. Friesians) or their crosses. As is common throughout the highlands, Central Kenya farmers keep a large number of poultry. Somewhat unique to Central Kenya is the investment in commercial production of chicken meat and eggs.

Woodlots are very common, and species and level of household involvement in planting are well documented. In the western highlands woodlots consist overwhelmingly of *Eucalyptus* spp. In Central Kenya, the dominant tree on the landscape is *Grevillea robusta*, grown by 86–94% of households on the boundaries of their holdings (used to demarcate boundaries). Aside from *Grevillea*, macadamia trees are the most well known and provide a good income.

Agricultural investment

Diversification into higher value agricultural enterprises is a strategy pursued by many farmers in the central highlands of Kenya. This strategy requires good access to markets and the ability to produce a range of profitable higher value crops. In the central highlands, farmers grow 6–7 different crops on average. This diversification and intensification within a smaller land area is a cushion against risky markets as well as farmers' recognition of farming as a business and not just as a way of life. In areas where farmers are not well linked into market opportunities, such as certain areas of Western Kenya, there has been little incentive to alter production patterns.

In the Mt Kenya highlands, there was introduction of crossbred and exotic cattle and a shift from paddock grazing to zero grazing. This resulted in intensive production of smaller herds of cattle. Some of the recent investments among Central Kenya dairy farmers are in feeding regimes such as napier grass and fodder trees. In Western Kenya, one striking difference from the central highlands is the lack of investment in higher grade cattle or accompanying investments in zero grazing.

Farmers in the central highlands make significantly more investments in soil management than their counterparts in the western highlands. A high proportion (75–92%) of Central Kenyan farmers apply fertiliser on maize, potato and coffee, and over one-half of these farmers apply manure to all their crops. Rates of fertiliser application are also high in Central Kenya. In Western Kenya, the amount of investment in land is more varied, with the Vihiga–Siaya cluster having relatively little investment. Only about 20% of households use fertiliser on a regular basis, and the amounts used per hectare have been found to be about one-fifth of those in the central highlands. A substantial number of farmers in Kenya use animal manure or compost.

In terms of labour allocation, there is strong evidence that cash crops take precedence over food crops. Men and women both invest more labour in cash crops than in food crops, and women provide the bulk of labour for most activities except for the raising of livestock.

Driving factors underpinning agricultural investment

There is a strong link between the proportion of crops marketed and the value of crop production or crop mix. Improved crop markets seem to strongly influence cropping choices of farmers. Expansion of market opportunities in Kenya has been strong in the dairy sector. Complementing the influence of markets for outputs has been the availability of credit for farmers in the central highlands. This is one success of the government supported co-operative sectors in coffee and tea. These credit sources are largely unavailable to smallholders in the western highlands and there are no other major sources that might fill this gap.

Household wealth is associated with many of the investments discussed above. For example, in Western Kenya, the relatively wealthy have larger farms, more cattle, a

higher proportion of cash crops and more prevalence of hybrid maize and fertiliser. One study found that the non-poowesternr spent approximately US$ 100 per year on agricultural inputs while the very poor spent only US$ 5.

Impacts of investment and land management choices

In terms of gross margins (excluding own labour), it is clear that coffee and tea are far superior to food crops like maize, potato and beans. Gross margins per hectare for coffee and tea are between 2 and 8 times larger than those for the food crops. Returns from livestock farming are also relatively high. Another study shows that the share of land under cereal crops greatly exceeds the contribution of cereals to crop revenue. Thus, the central highlands have not only diversified into higher value crops, but have selected very profitable ones. By contrast, though there is some diversification in the western highlands, industrial and horticultural crops (e.g. sugarcane, kales) are not providing an incremental gain in revenue. The productivity level in the central highlands is 3.5 times that in the western highlands. In the central highlands, average total income has been estimated at US$ 2819. Of this, 39% or US$ 1099 came from crops and 24% from livestock. Households in the western highlands earned 32% of income from crops and 29% from livestock. However, total income for western highland households averaged only US$ 1014.

Despite large differences in productivity and income at the regional level, one can find successful and unsuccessful farmers within each region, indeed within each village of Kenya. It has been found that the very poor suffered from negative nutrient balances and poor nutrient stocks, poor crop yields and almost no visible farm profits. Average annual maize yields were 880 kg/ha for the very poor compared to 3080 for the non-poor. The profits of the very poor were only US$ 3 per year as compared to US$ 545 for the non-poor.

Lack of wealth may also inhibit investments in new higher value crops. Many require capital for items such as seedlings, irrigation and sprayers, as well as access to working capital for seasonal inputs. Thus, the critical question facing policy makers is how to most efficiently and effectively catalyse movements among the rural poor towards improved livelihood systems.

Summary and ways forward

In the Kenyan highlands, market development of higher value agricultural enterprises seems to be the critical need. Households demand and consume a wide range of food products and it is not feasible for households to produce all of these at sufficient levels. They also spend most of their cash on food. Household food security would benefit significantly from enhanced income sources—including or especially from increased crop, livestock and tree productivity.

There are many examples of successful intensification in the central highlands. For this region, a key foundation has been either coffee or tea, both export crops with a ready buyer and supplier of inputs on credit (parastatals). With these pillars in place, new commercial-oriented enterprises such as dairy, macadamia, pyrethrum, vegetables and fruit trees were easy to accommodate. This type of development pathway has escaped the majority of the western highlands. One factor has been the lack of parallel development of infrastructure for processing coffee and tea and to service high quality animals. Cultural aspects may also play a role, as ethnic groups in Central Kenya are recognised for their market/economic prowess. The end result is that much of Western Kenya has followed the development strategy of diversifying into non-farm activities. For the poor, this often means seeking jobs as agricultural labourers, or relocating to Nairobi to work in the low-paying informal sector. This strategy has yet to pay off for the majority of households.

It is worth exploring the possible ways forward in agriculture in the western highlands. In the Siaya-Vihiga area, the ten most commonly sold items are vegetables, chickens, fruits, poles/timber, milk, maize, fuelwood, beans, eggs and cattle/goats. Of these, some are feasible for households with little cash. These would include short-term enterprises such as certain types of vegetables (e.g. kales) but not others (e.g. tomatoes, which require significant pest and disease control) and chickens (starting on a small scale). Longer-term investments in trees for fruits, poles/timber and fuelwood are also feasible in terms of requiring little cash, but require land and patience. How can households finance these investments? There are several other opportunities for generating small sums of cash without having to invest cash. These include the application of organic nutrients to existing crops that can boost yields and, thus, incomes. The major question is whether these incremental gains can be used to fuel further investment in agriculture, because the competition for cash from different consumption needs is acute.

Comments *by Isaac Minde*

The methodology and results of this study have a high probability of being extrapolated to other pockets within the region that have similar characteristics. The study, however, does not seem to have sufficient references to past work in this area. One would have expected the study to build on and relate to work, for example, by Ruthenberg, Collinson etc. in this geographical area. There are a number of related issues where one would have liked to see what changes have taken place over the years. On more specific issues:

- The claim that woodlands are not profitable may need to be substantiated. Under what conditions are they unprofitable?
- It is just an observation that points to the challenge on African agriculture. The farming system is described as 'there being six types of crops on the farm but paradoxically the income is still less than US$ 1 per day'.
- There is an assertion that reduction in livestock numbers in the study area is due to reduction in farm size. I would think that even if the farm sizes were to increase

today, one would not expect more livestock because the current generation is experiencing better pay-offs off the farm than on the farm.

- On the question of inputs, particularly fertilisers, mere counting of farmers who use fertilisers without the quantity used does not give us much information. Some just use a trace of it, which leads to little or no effect.
- The issue of food and cash crops is a confusing classification. For example, maize is considered as food, but in other places, it is shown that maize brings in more cash than coffee. Perhaps, it may be better to use export vs. food crops classification.

Land management problems and potentials in the Lakeshore intensive banana–coffee farming system

D. Sserunkuuma

Makerere University, Uganda

This study was motivated by the purported shift in production of cooking bananas (*matooke*) from the lakeshore intensive banana–coffee farming system to south-western Uganda, due to several factors including increased pest and disease pressure and declining soil fertility. Because of its endowment of high population density, good market access and medium to high agricultural potential, the lakeshore banana–coffee farming system has the highest economic potential among all rural areas in Uganda, with the intensive production of high value perennial crops such as coffee and *matooke* being one of the most profitable pathways of development (common pattern of change in livelihood strategies) hypothesised for this region. Other potential agricultural pathways include intensive production of livestock products, high value perishable annual crops such as vegetables and low value storable annuals such as maize and beans.

Different development pathways have different impacts on land management, productivity and other resource and welfare outcomes. For example, if it is true as literature alleges that the decline in yield of *matooke* (a perennial crop) in the lakeshore region has resulted in its replacement by annual crops (such as maize), which leave the soil more exposed to erosive forces, then the apparent increase in soil erosion, estimated to be above the tolerable rate of 5 t/ha per year, is not surprising. It is estimated that soil erosion and other avenues of soil nutrient loss have caused a loss of 80–100 kg of NPK/ha per year in the lakeshore region and other parts of central Uganda.

Proceeding along the above described maize-expansion pathway of development, without investing in land improvement would result in a downward spiral of decreasing soil fertility and crop yields in the region, with serious implications for food security and poverty. On the other hand, adopting the intensive pathway (increasing investment in soil and water conservation and use of external inputs to replenish soil nutrients) could improve land conditions, current and future agricultural productivity and welfare outcomes.

This paper adopts a narrow definition of intensification (use of external inputs such as improved seeds and animal breeds and the use of inorganic fertiliser or manure to maintain or enhance soil fertility) to address two key questions. The first question is about changes in development pathways involving the production of key crops and livestock in the lakeshore region and whether or not there is a tendency towards intensification as predicted by earlier studies. The second question is what influences (constrains or enables) farmers to intensify?

The data used to answer these questions is part of a bigger data set obtained through a survey of 451 households sampled from 107 LC1s (lowest administrative unit in Uganda) in central, eastern, western and northern Uganda. From each of these LC1s, four households were randomly selected for household and plot-level surveys to gather information on nutrient flows and household socio-economic characteristics. Out of the total sample of 451 households, 137 (30%) were from 8 of the 10 districts that make up the intensive lakeshore banana–coffee farming system (Mukono, Mpigi, South Luwero, Mubende, Rakai, Masaka, Iganga and Kamuli). Two districts (Kalangala and Wakiso) were left out because Wakiso was part of Mpigi district when the surveys were conducted and Kalangala lies outside the study area. This paper thus focuses on the 137 households from the intensive lakeshore banana–coffee farming system to address the research questions.

The study results show that the production and sale of crops was the most common primary and secondary income source in 2000, mentioned by 67% (primary) and 34% (secondary) of households, and the proportion of households depending on crops as their primary source of income increased by over 16 percentage points between 1990 and 2000. During the same period, the production and sale of livestock and livestock products also grew in importance (though slightly) as a primary and secondary income source. The major livestock and crop enterprises that grew in importance during this period include cattle, pigs, poultry, banana, coffee, maize and beans. The proportion of households depending on trading in agricultural outputs and inputs as a primary and secondary income source also increased during the 10-year period, making it the second most common primary income source and third most common secondary income source. This could be a result of the liberalisation of trade in agricultural inputs and outputs, which increased the number of traders dealing in agricultural products and stimulated production for the market (increased commercialisation of agriculture).

Of the three food crops (maize, beans and bananas) that gained importance in the 1990s, maize is most important as a commercial crop because it has the highest proportion of total output sold (29%) and its contribution to household crop income (22%) is equal to that of coffee and is higher than both bananas and beans. This has serious implications for land management. As already mentioned, maize production exposes land to forces of erosion because it does not provide a good soil cover. In addition, it is associated with export of nutrients from the farm via commercialisation, which leads to nutrient mining if nutrients are not replaced by use of external inputs. Thus, the nutrient loss associated with maize production and export from the farm implies increased land degradation unless improved land management practices (such as use of external inputs) are adopted.

About 72 and 70% of the 137 households in the lakeshore region produced maize in the first and second cropping seasons, respectively, in the year 2000. A lower, but substantial proportion of households (44 in the first and 40% in the second season) grew improved varieties of maize. This shows a high level of adoption for improved maize varieties. However, the proportion of households using inorganic fertiliser, manure and compost on maize is very low (ranging between 0 and 3%), and so is the average quantity of these inputs used. The implication is that many farmers are adopting

high-yielding maize varieties that mine more nutrients from the soil (through increased harvests) without using external inputs to replenish the lost nutrients. This piecemeal adoption of improved seed–fertiliser technology packages will cause nutrient depletion, unless farmers are encouraged or supported to begin replenishing the lost nutrients. The case for beans is quite similar to that of maize.

Sixty eight percent of the surveyed households grew cooking bananas (*matooke*) in 2000, and about one-fourth of these applied manure, and a lower proportion applied compost (nearly 7%). On average, 417 kg of manure and 51 kg of compost per household were applied to bananas in 2000. No household used inorganic fertilisers on bananas. Fifty-seven percent of the surveyed households grew robusta coffee in 2000, but only two of these households applied inorganic fertilisers and one household applied compost to coffee fields in 2000. A bigger percentage of households (10 in first and 9% in second season) applied manure to coffee fields, and on average, 152 kg of manure per household were applied to coffee fields in the year 2000. The percentage of households keeping improved breed cattle (crosses and pure breeds) increased from 9% in December 1990 to 12% in December 2000. The average percentage of improved breed cattle in the herds held by surveyed households also increased from 5% in 1990 to 10% in 2000, implying increased (albeit slight) intensification among cattle farmers. The proportion of households that kept improved breeds of pigs and chicken was very low both in 1990 and 2000, ranging between 0 and 3%.

Overall, the current level of intensification in crop and livestock production in the lakeshore region seems to be insufficient to bring about the improvement in soil fertility and agricultural productivity needed to reduce poverty and food insecurity in the region. Although a significant proportion of farmers are using improved varieties of maize and beans, this alone is not enough to sufficiently enhance yields. Instead, it increases the rate of soil nutrient mining and negatively affects current and future crop yields. It is imperative that the use of external inputs be increased to replenish lost nutrients. The use of inorganic fertilisers is almost non-existent but some households are using manure and compost on bananas and coffee. The use of improved breeds of livestock is also low. These results are consistent with the findings of an earlier survey of 107 LC1s and villages that the banana–coffee expansion pathway was most strongly associated with adoption of soil and water conservation practices, while the cereals expansion pathway was not associated with adoption of soil and water conservation practices.

Despite the fact that a growing number of rural households in the lakeshore region are embracing agricultural production as their primary income source, the existing opportunities for increasing their incomes through greater intensification are not being exploited. Several factors were hypothesised as deterring farmers from pursuing the intensive pathway, including lack of supporting systems such as credit, extension, or agricultural training programmes, lack of labour and capital (natural, physical, financial, human and social) or savings, land tenure insecurity, lack of access to markets etc. However, the effect of a few of these variables such as land tenure, access to credit and savings has not been analysed because of the problem of small number of observations on these variables. The econometric results show that contact with extension agents, market access and livestock ownership (pigs and cattle) significantly enhances the

application of manure on bananas, while farm size (total land endowment of the household) negatively affects it since larger farms can increase or maintain production using extensive methods which may not be possible for smaller farms. The positive effect of market access on manure use is probably because farmers with better access to markets receive better prices than those with poor market access, which induces them to use yield-enhancing inputs (such as manure) to increase yields and take advantage of the better prices. The fact that livestock ownership enhances manure use shows that farmers mostly rely on own supply of manure because of its low value to volume ratio makes it less tradable.

Population density (which contributes to farm size reduction) and cattle ownership significantly enhance manure use on coffee. Both the probability and intensity of use of improved maize varieties are enhanced by membership in organisations and distance to nearest markets as expected, although market access has a negative effect contrary to *a priori* expectation. It is hard to explain why market access would reduce adoption of improved maize seed. It may be associated with presence of better paying alternatives in areas with better market access. The positive effect of organisations on adoption of improved maize varieties suggests that some organisations are promoting their use.

To conclude, the production of several crops and livestock has gained importance, the most notable ones being cattle, pigs, chicken, perennial (*matooke* and coffee) and annual crops (maize and beans). Associated with the production of annuals (especially maize), however, is increased nutrient mining through increased exposure of soil to erosive forces and nutrient exports from the farm through commercialisation, unless external inputs (such as inorganic fertilisers, manure, compost etc.) are used to replenish them. Unfortunately, the level of use of such inputs on annuals (maize and beans) is near zero, although some farmers are using manure and compost on perennials (*matooke* and coffee). Instead, a significant number of farm households are growing improved (higher-yielding) varieties of these annuals, which take out more nutrients from the soil than the low-yielding unimproved varieties, without replacing them. Moreover, a significant proportion of the annuals (maize in particular) is sold for cash, leaving no chance of recycling the nutrients lost through harvesting. The end result is bound to be faster land degradation.

The study shows that livestock ownership (particularly cattle), contact with extension agents, population density and market access significantly enhance the use of manure on perennials (bananas and coffee). Thus, improving farmers' access to markets through investments in rural road construction and maintenance as well as transportation is likely to result in improved land management in the lakeshore region. The positive influence of livestock ownership and access to extension on manure use suggests that extension services are correctly using the opportunity of increased livestock acquisition (especially cattle) in the region to promote the use of manure on perennials. This effort needs to be expanded to include other types of livestock (such as chicken) and crops (such as maize) to ensure that synergies between all crops and all livestock (not just cattle manure and perennials) are fully exploited to improve land management in the region.

Membership in organisations is associated with increased use of improved maize seed, suggesting that this technology is being promoted by some organisations in the Lakeshore

region. However, the limited use of soil fertility replenishing inputs associated with maize production implies that these organisations are not promoting the use of these inputs as much as they are promoting improved seed or that farmers are only adopting the seed but not fertilisers. This is bound to deplete soil fertility in the long run and it is critical that such organisations put as much emphasis on soil fertility management as they do on improved seed to ensure that increased maize production in the lakeshore region does not come at a cost of increased land degradation.

The negative effect of farm size on manure use suggests that smaller farms are more likely to use manure than bigger ones. Thus, population pressure, which reduces farm size may not necessarily promote land degradation as the Malthusian pessimists have always argued, but may instead stimulate investments in land improvement. Consistent with this, population density significantly enhances the use of manure on coffee.

Comments *by Isaac Minde*

This is a very enriching paper in terms of knowledge about the dynamics of the farming population with special reference to 1990 to present. However,

- The reason for taking the baseline to be 1990 must be justified. One of the reasons is that before 1990, too many factors external to the farm were impinging on the households.
- The assertion that there is an increasing number of households in the lakeshore who are leaving non-farm employment and turning to agricultural production and trade as a primary source of income is not convincing. In many places, it is just the reverse. At the same time, it is being noted that the production of *matooke* has had some decreasing yields.
- On the question of nutrient mining, it has to be noted that each crop brings with it its own share of nutrient mining. So, it is only a matter of degree, as there is no crop that does not mine the soil without replenishment of nutrients.
- A more detailed analysis of the agricultural credit aspect would have been very useful to this study. It seems that the author just glossed over it.

Policies affecting land management, input use and productivity: Land redistribution and tenure in the highlands of Amhara region, Ethiopia

S. Benin

International Livestock Research Institute (ILRI), Ethiopia

Using data from household and plot level surveys conducted in the highlands of Amhara region in 2000/01, this paper presents evidence and implications of the impacts of land redistribution and land tenure contracts on land investments and management practices, input use and productivity. The paper also examines the impacts of other policy and programme variables including education, access to infrastructure (irrigation, roads, markets), credit and extension, while controlling for many factors (including household structure and endowments, plot quality, agricultural potential, population density) that may affect land management, input use and productivity.

The nature of tenure on a plot of land can affect land management and productivity on that plot for several reasons. If land tenure is insecure, then the household operating the plot may have less incentive to invest in land improvement. However, the household may increase investment if this can in turn increase security of tenure. In Ethiopia and particularly the Amhara region, one major source of tenure insecurity derives from land redistributions, which have been frequent and ongoing since 1974. Although land redistribution may cause tenure insecurity, it may have mixed impacts on farmers' land management and productivity, through short- and long-term effects. Expectations of future land redistribution may undermine farmers' incentive to invest in land improvements and soil fertility, since farmers' ability to reap the long-term benefits of such investments is undermined. However, redistribution may also improve access to land of households that have relative surpluses of other important factors of production, particularly in the context of prohibited land sales and restricted lease markets. Thus, land redistribution may increase intensity of land management and use of purchased inputs, which may in turn increase productivity.

The ability to transfer land (through temporary leases in the form of sharecropping, fixed-fee rentals and borrowing) can help households who own little or no land to overcome land constraints, and also help those with little or no inputs (especially oxen and labour) to lease out the land and obtain capital to engage in other income-generating activities. However, the efficiency of alternative land tenure contracts has generated a lot of discussion in the past and it is still very much debated. Underlying this debate is the incentive that the alternative contracts provide to the tenant. Generally, given imperfections in factor markets, as exist in developing countries, the efficiency of alternative land tenure contracts remains an empirical question.

It was found that about 89% of the plots were cultivated by the 'owners' (recipients of land through prior redistribution or inheritance). The remaining 11% were obtained through temporary farmer-to-farmer exchanges in the form of rental, mostly share-cropping. Of the plots cultivated by the owners, 14% were obtained during the recent land redistribution in 1997 and 1998. It was also found that a low incidence of land investments, mostly drainage ditches, followed by stone terraces, fences, live fences and grass strips exists. Land management practices were restricted to a few conventional types including contour plowing, incorporating crop residues and crop rotation. Use of reduced tillage, fertiliser, household refuse, improved seed and manure were also reported on several plots.

Econometric analysis was used to investigate the effects of land redistribution and tenure contracts as well as other policies and programmes on: 1) farmers' land investments (stone terraces, drainage ditches, fences and live fences/barriers) in metres per hectare since 1991; 2) farmers' land management practices (use of manure, fertiliser, improved seed, household refuse, crop rotation, plowing in crop residues, reduced tillage and contour plowing) in 1999; 3) farmers' use of inputs (labour, draft animal, seed, fertiliser and manure) in 1999; and 4) crop yield (value of total output per hectare) in 1999.

Land investments

Plots acquired through land redistribution since 1991 were associated with more fences, but fewer live fences. Compared to rented plots, owner-cultivated plots were associated with more stone terraces and fewer fences. Probably, farmers cultivating their own plots are more secure and so have more incentive to undertake long-term beneficial conservation measures, compared to renters who may have more immediate needs to protect their crops. Expecting to operate the plot for the next five years was associated with more live fences but fewer fences (using non live materials), reflecting the substitution of long-term investments on more secure land for easy-to-dismantle structures on less secure land.

Contact with an extension agent was associated with more drainage ditches, fences and stone terraces. Use of external credit (e.g. from the Amhara Credit and Savings Institution (ACSI)) was associated with less stone terraces, while use of local credit (e.g. from an *equb* group) was associated with more live fences but fewer fences. Credit given by ACSI is in the form of fertiliser and improved seed, which are more likely to be used on relatively flat surfaces or where there is assured water supply (e.g. irrigation) and, thus, where moisture-conserving structures are unnecessary.

Better access to an all-weather road increases investments in live fences. Population pressure was associated with a reduction in fences, probably due to increasing pressure on the demand for wood and other fence material (e.g. twigs and branches with leaves) for fuel.

Land management practices

Land redistribution was associated with greater likelihood of using fertiliser and reduced tillage, although it was associated with lower likelihood of incorporating crop residues. These results suggest that younger households, who are the primary beneficiaries of land redistributions, may be more educated and more able and willing to use fertiliser, reducing the need for incorporating crop residues. However, younger households may also face labour and oxen constraints, forcing them to plow their plots less. In support of this, it was found that households operating redistributed plots also had fewer members and owned fewer oxen (and other livestock). Compared to rented plots, owner-cultivated plots were more likely to have contour plowing and rotation of crops, but less likely for improved seed to be used. As management practices, contour plowing and crop rotation have long-term beneficial effects and, therefore, would be preferred on the more secure owner-cultivated plots.

Use of credit increases the likelihood of using fertiliser and improved seed. Generally, contact with an extension agent was associated with intensification, greater likelihood of using fertiliser and improved seed and incorporating crop residues. Furthermore, higher frequency of this contact (five or more) was associated with greater probability of using manure and contour plowing while, less than five contacts was associated with less application of household refuse. These results suggest that repeated contact with extension agents is needed to have a positive impact on long-term soil fertility management.

Irrigation was associated with greater likelihood of using several land management practices, including manure, household refuse and fertiliser. Better access to markets also increases the likelihood of using manure, household refuse and fertiliser, probably because better access to the market town raises the value of land by raising farm-gate prices, thereby encouraging investment in land management. Similarly, better access to an all weather road increases the likelihood of incorporating crop residues. Population pressure reduces the likelihood of using contour plowing, although it increases the likelihood of incorporating crop residues and using improved seed, reduced tillage and crop rotation. Some of these findings may be due to the negative impact of population pressure on ownership of oxen, thereby reducing the capability of households to plow, while easing the demand on crop residues for feed and increasing the likelihood of recycling it in the soil.

Use of inputs

Plots acquired through land redistribution received less labour and manure per hectare. These results may reflect the labour and livestock constraints facing beneficiaries of the redistribution (mainly younger households). Compared to rented plots, owner-cultivated plots received less fertiliser but more manure per hectare, reflecting choice of fertilisation

technology to suit the land tenure; usage of fertilisation methods with long-term benefits on more secure plots and those with immediate benefits on less secure plots.

Use of external credit was associated with increased use of all inputs, although use of local credit was associated with increased use of seed only. Extension also had positive impacts: contact with an extension agent was associated with increased use of seed and fertiliser; in addition, more than five contacts was associated with increased use of draft animal and manure.

Irrigation increases use of all inputs (labour, draft animal, seed, fertiliser and manure). Access to markets or all weather roads had little impact on input use, except where being closer to a market was associated with declining use of draft animals, and being closer to an all weather road was associated with declining use of labour. The lack of impact of better market access (i.e. being closer to a market or all weather road) on use of fertiliser may reflect the dominance of accessing external inputs through the government credit and extension, rather than buying from the open market. Increasing population density was associated with declining use of draft animal and manure, probably due to constraints on feed availability for draft animals in more densely populated areas.

Crop production

In addition to input use (draft animal, seed and fertiliser) and land management practices (use of manure, fertiliser and improved seed) that were found to have significant impacts on value of crop production per hectare, oxen ownership, extension and population pressure had significant direct impacts on crop production. However, land distribution has no consistent significant impact on yield. Furthermore, there were no consistent significant differences in yield between owner-cultivated and rented plots, suggesting efficiency in the land rental market in the highlands of Amhara region. While this finding is consistent with results of a study on some villages in Oromiya region, it contradicts results from studies in Tigray region.

Overall, these results suggest that using land redistribution as a tool to address the increasing problem of landlessness in the highlands of Amhara region is not necessary, as long as the current land lease market is allowed to operate freely and without restrictions. This is a very important implication, especially given imperfections in other factor markets (e.g. oxen rental). Restrictions, for example, on the maximum size of land that can be rented out (as exist in Oromiya region) or on the maximum lease period (as exist in Tigray region), can confound the incentive problems associated with land renting and can lead to reduced farming intensity and crop yields. Although not studied here, results of a study of farm households in southern Ethiopia show that renting out a plot of land increases tenure insecurity by increasing the likelihood of that land to be redistributed. Thus, it seems that ending future land redistributions in Amhara region (which is currently being considered by the regional government) could strengthen the efficiency of the land rental market.

To the extent that investments in land improvement are necessary for conservation purposes, it appears that ending future land redistributions alone will not have much impact on reducing land degradation. However, ending redistribution, in addition to allowing the current rental market to operate freely and encouraging longer leases may have more impact on addressing the land degradation problem.

It was also found that yield was about 32–44% higher on manured plots, 65–82% higher on fertilised plots and 29% higher on plots using improved seeds. In general, extension had a positive impact on crop production, although only households with frequent (more than five) contacts with an extension agent showed a significantly higher yield (29%). About 34% of the households surveyed did not have any contact with an extension agent, while 30% had fewer than five contacts in the year. Thus, there is great potential for improving land management and productivity by increasing the extension coverage and also the frequency of contacts. Increasing ownership of oxen was also associated with an increase in yield (25%). Although ownership of oxen in the region is relatively high (average of 1.6) and only about 14% of the households did not have oxen, the development of and improvement in oxen sharing, lease arrangements or other mechanisms for obtaining plow services will be important, however. Increasing population pressure was associated with declining yield (13%), most likely due to the negative impact on ownership of oxen, which is critical in timely plowing of plots. Thus, policies and programmes that reduce population pressure will be useful.

Comments *by Stein Holden*

This is a good and rich paper. It focuses on some of the most central policy issues of Ethiopia over the past 30 years. It is true that there may be little to gain from continuing with land redistributions (except greater equity in land distribution) in the future in the same way as was done in the past. Thus, policy makers should instead focus on how to improve rental markets for land and oxen, as these markets appear highly imperfect. What could be done to stimulate oxen owners to rent out their oxen to households who do not have oxen? Overstocking of oxen and low land productivity for non-owners of oxen may be important effects of these inefficiencies in rental markets for land and oxen.

However, the paper does not provide any strong evidence on the negative impacts of past land redistributions. Some variables are missing in the regression results that could have provided additional insights on this. Especially, the paper does not build on the extensive literature on the relationship between farm size and land productivity, nor the literature on land fragmentation. Inclusion of the variables on farm size and plot size (while testing for non-linear relationships) could have provided more useful insights. Continued land redistributions would probably have a negative effect on land productivity if small farms and small plots are less productive than large farms and large plots. This, however, requires careful control of land quality differences etc. between plots and

farms. This could be achieved using land quality variables and village fixed effects models.

The paper also relates to the share tenancy literature. No evidence of inefficiencies in relation to share tenancy was found in the Amhara region while such inefficiencies were found in the Tigray region. One may wonder why.

Land productivity of female-headed households has been found to be much lower than that of male-headed households. Sex of household head was not included in the analysis in this paper. This gender dimension may be important and should not be ignored. Its significance is also a sign of market imperfections. It is an empirical question whether these market imperfections represent market failures that should be corrected through policy interventions.

There is a forthcoming paper in which we found that tenure insecurity has little impact on short-term production efficiency through input intensity. We also found that poverty may be a more important constraint to long-term investments, like tree planting, than tenure insecurity in southern Ethiopia. Tenure security is therefore a necessary but not sufficient condition for long-term investment incentives.

Livestock, livelihood and land management issues in the highlands of Ethiopia

M.A. Jabbar, M. Ahmed, S. Benin, Berhanu Gebremedhin and S. Ehui

International Livestock Research Institute (ILRI), Ethiopia

Introduction

Livestock perform multiple functions in the Ethiopian economy and its people by providing food, input for crop production and soil fertility management, raw material for industry, cash income, saving, fuel, social functions and employment. Therefore, livestock can serve as a vehicle for improving food security, better livelihood and sustainable land management and contribute significantly to agricultural and rural development. Ethiopia has the largest livestock population and the highest draft animal population in the continent, yet productivity is generally lower than in comparable African countries and national and per capita production of livestock and livestock products, export earnings from livestock and per capita consumption of food from livestock origin have declined since 1974. It is often argued that increasing population pressure has led to deforestation and conversion of pastureland into cropland, leading to overstocking and overgrazing and degradation of remaining pastures. Crop residues are increasingly used as feed and fuel rather than as mulch to maintain soil moisture and fertility, due to shortage of pasture and fuelwood. Similarly, dung is used as fuel rather than as manure. All of these contribute to land degradation through enhanced erosion and nutrient depletion.

Livestock received less policy support in the past in terms of research, extension, technology dissemination, investment, credit and marketing infrastructure, which limited its potential contribution to national development. If the contribution of livestock to the national economy is to be enhanced, as envisaged in the current Agricultural Development-Led Industrialisation (ADLI) strategy, technology and policy interventions need to be based on objective assessment of the potential and constraints of livestock development in different socio-ecological domains. This paper assesses factors that influence livestock holding, livestock population mix and dynamics and how they relate to land use, management and land degradation. It also discusses factors that influence different economic functions of livestock, especially income, saving and expenditure and the implications of the findings for livestock development under different socio-ecological domains.

The analysis is primarily based on extensive community and household surveys in the highlands (>1500 metres above sea level, masl) of Amhara, Tigray and Oromiya regions during 1998–2001. The samples consist of 49 peasant associations (PAs), 98 villages and 433 households in Amhara, 50 PAs, 100 villages and 500 households in Tigray, and 85

PAs and 120 households in Oromiya regions. Data were collected for 1991 and 1999 on a recall basis to assess recent changes.

Summary of findings

Livestock perform multiple functions in the smallholder crop–livestock systems in the highlands of Ethiopia, but the highlands not being homogenous in terms of ecology, market access, population density, resource endowments and production systems, the nature and magnitude of livestock's contribution to livelihood strategies, income and saving vary across regions, communities and households. Though it is commonly perceived that there is an overpopulation of livestock in the highlands of Ethiopia and national statistics show an increasing livestock population and a decreasing feed resource base due to human population pressure, the surveys conducted in the three regions show a general decline of livestock population except in a few cases where oxen and donkey populations have slightly increased. In addition, the proportion of households owning different types of livestock and average holding per household declined significantly in 1999 compared to 1991. Population density, market access, ecological condition, land redistribution, primary and secondary activity of households, household size, stock of animals in the base year, principal and secondary feed sources, terms of trade between crop and livestock and access to credit are some of the most important factors that influenced the changes in livestock ownership between 1991 and 1999. However, the set of factors influencing change of ownership were not the same at community and household levels, among the three regions, and between different ecological zones within each region.

Whether reduced livestock population led to increased productivity is unclear because there has also been significant reduction in the traditional feed resource base such as common and private grazing land, bush and forest. Consequently, pressure on pastureland increased rapidly, resulting in significant decline in quality. The only exception was Tigray, where there was a slight trend of improved quality (reduced erosion) of the common grazing land due to village level management rules and enforcement of such rules.

It is generally contended that cow dung and, in many cases, crop residues are mainly used as fuel due to shortage of fuel wood, hence the traditional nutrient cycling in the crop–livestock system is broken, leading to reduced soil fertility and erosion. However, in the Oromiya region, use of dung and crop residues as primary or secondary sources of energy is not widespread. These practices are most common in the high and low potential cereal zones (HPC and LPC), but not in the perennial zones. Plot level soil fertility management strategies used by the sample households show that manure or compost use, plowing in crop residues and grazing crop residues were practised on 22, 37 and 60% of the plots, respectively, in both 1991 and 1999. While DAP was applied on 18% of the plots in 1991 and 33% in 1999, urea was applied on 5 and 19% of the plots in 1991 and 1999, respectively. Thus, it appears that a nutrient extracting practice (grazing

crop residue) was more common while nutrient replenishing practices were less common. Since soil erosion and fertility were more serious problems in the HPC and LPC zones as indicated earlier, it seems logical to argue that diversion of dung and crop residues for uses other than land management in these zones indirectly contributes to land degradation.

Although livestock is an essential component of smallholder mixed farming systems in the highlands, it is not yet a primary activity or source of income for a significant number of communities or households. For example, in the Oromiya region, livestock ranked third on average out of the top five cash income sources and are a secondary/tertiary activity or source of income for about 40% of the households. Variety in the types of livestock owned significantly improved livestock income and total herd size significantly influenced cash income, while oxen ownership significantly improved total income but reduced crop income. Credit and extension, which is primarily crop-biased in the region, did not have any effect on livestock ownership or income. In the Amhara region, livestock-based activities as livelihood strategies were mainly located far away from a road or market, and land holding size had no effect on adoption of livestock-based activities as livelihood strategies. However, livestock income was higher near to a road or market and for households with chicken or bee keeping as livelihood strategy, but lower for credit users. The overall return on livestock in 1999/2000 was negative due to loss of stock after a serious drought in the previous year.

The proportion of households using livestock as their primary or secondary form of saving declined from about 48% in 1991 to about 34% in 1999, and there was an increase in cash saving. This is an indication of the increased monetisation and access to financial infrastructure in the rural economy. If livestock can thus be used to diversify and generate more income, as indicated to some extent by the above, a reduction in its traditional saving function need not be a cause for concern.

Livestock technology adoption

The decline and degradation of traditional feed resources appears to be a major reason for the perceived low livestock productivity. This could be compensated for by adoption of improved feeds (planted forages, purchased feeds), better breeds and veterinary inputs. However, adoption of improved technology involving cash expenditure is unlikely if the enterprise is not market-oriented. If the product is produced to earn cash income rather than subsistence, the profit motive will play a greater role in technology adoption.

Since livestock production was not a sufficiently market-oriented enterprise in the majority of the communities and households, adoption of improved technologies and services remains low. For example, in Amhara region, only 19–25% of households used purchased feed (not all of high quality), while 33% of households used animal health services in 1991 and 55% in 1999. In only up to 26% of communities did some households use improved breeds or artificial insemination. Yet returns to livestock in 1999 were negative due to high mortality and loss of stock. In Tigray, 19 and 38% of households used animal vaccine and purchased feed, respectively in 1991, 73 and 40%

in 1999, and there is evidence that the overall return to livestock, especially small stock and bee keeping, was profitable. In Oromiya region, only 7% of the sample households used improved breeds and vaccines. In this region, dairy with crossbred cattle and improved feeds are found principally in the urban/peri-urban areas, which were not included in the samples. Thus, it appears that livestock development through improved technology adoption is still at a rudimentary stage in the majority of the rural communities.

Conclusion

It appears that in the semi-subsistence smallholder crop–livestock systems in the highlands, livestock are facing serious competition for resources from people in spite of their multiple functions. Since cereal crop production remains a major livelihood strategy, as over 49% of the population live below the absolute poverty line, this situation at this stage of development is perhaps not unexpected. These are also the reasons for low adoption of productivity-enhancing technologies. In high market access areas, investment in livestock, especially small stock, appears to be profitable though more people apparently raise livestock as a livelihood strategy in distant areas, perhaps because non-income functions are more important motivating forces there. However, as the economy becomes more monetised and livelihood strategies are chosen more in response to market opportunities based on comparative advantage, livestock should appear as a suitable enterprise in many socio-ecological domains. Priority for support services for livestock development, for example, extension, credit, marketing, feed and breeding and health technologies, should be targeted to such domains.

Comments *by Ephraim Nkonya*

The livestock population in Ethiopia is the highest in Africa. This makes the livestock sector in Ethiopia an important sector. However, its contribution to the national and individual household incomes is low. The need to understand the livestock sector and the factors behind its dismal performance are therefore important research questions. This paper addresses these important issues and links them to livelihood strategies and land management in the highlands of Ethiopia. The major contribution of the paper is that the authors provided empirical evidence of the role of livestock in the livelihood of farmers in the highlands of Ethiopia. There was also a short discussion on the role of livestock in land management.

In general, the paper did not devote enough attention to policy implications of the findings. Only one short paragraph provides terse policy statements. Specific comments on policy implications that were not addressed in the paper are given in the following comments:

i. There was a lack of discussion on the role of livestock in land management. For instance there was no discussion on the association of animal waste use and number of livestock owned. A discussion on the relationship of livestock numbers and yield of major crops would also be important. Results on use of animal waste and crop yield relationship with livestock numbers would bear important policy implications on the crop–livestock interaction. One such policy implication is, do large numbers of livestock contribute to land degradation or help in improving soil fertility by increasing availability of animal waste used for crop production?
ii. The authors observe declining livestock numbers, which is contrary to what the national statistics show. Why this is so is not explained. Did the survey cover areas that have shown declining numbers or that the national statistics are less accurate? The changing livestock population is an important policy issue as it has a direct bearing on the national economy, rural livelihood and land management.
iii. Related to (ii), declining livestock numbers may be associated with intensification of livestock production. Was there such evidence? The paper is not clear on this. However, it is important to know the association of livestock numbers and adoption of improved animal breeds, feeding systems and animal health technologies. If there is evidence of inverse relationship between livestock numbers and intensification, the decline may not necessarily lead to decreasing income from livestock. This is of interest to policy makers.
iv. Related to (ii) and (iii) is how profitable are livestock compared to competing enterprises such as crops. Comparison of returns to labour for crops and livestock would shed light on why there has been declining number of livestock in the past 10 years. Policy implications of such findings may be discussed in the light of what may be done to increase the competitiveness of the livestock sector.

Community natural resource management in the highlands of Ethiopia

Berhanu Gebremedhin,[a] *J. Pender*[b] *and Girmay Tesfay*[c]

a. International Livestock Research Institute (ILRI), Ethiopia
b. International Food Policy Research Institute (IFPRI), USA
c. Wageningen University, The Netherlands

Introduction

Common property resources (resources owned and managed by a community) are important sources of fuelwood, timber, grazing land and irrigation water in many developing counties. However, these resources tend to be overexploited due to the absence of use rules and regulations or ineffectiveness of existing use rules and regulations. Several alternative solutions have been proposed to redress the problem of degradation of common property resources in developing countries. These include privatisation, state ownership, imposition and enforcement of use rules and regulations by external forces such as governments at different levels, or collective management by communities.

This paper evaluates the nature and determinants of community management (collective action) of woodlots and grazing lands in the northern Ethiopian highlands of Tigray. Common property resource degradation in Tigray is severe. Concerted effort to redress the degradation of natural resources is also underway, especially since 1991. Major strategies for environmental rehabilitation in Tigray include construction of stone terraces, soil bunds and micro dams; establishment and development of area enclosures (areas closed to human and animal interference to promote natural regeneration) and community woodlots (enclosures with enrichment plantations or areas of new plantations); and enforcement of use rules and regulations for grazing lands.

Results are based on data collected from 50 communities and 100 villages in Tigray through group interviews. Information was sought about changes in agricultural and natural resource conditions between 1991 and 1998, and their causes and effects. Analysis of descriptive information was used to identify the nature of management of woodlots and grazing lands, the roles of different organisations (local and external) in managing them, and the benefits and problems encountered. Econometric analysis was used to investigate the determinants of collective action and its effectiveness in managing these resources.

Woodlots

Community woodlots are widespread in the highlands of Tigray, with almost nine out of ten communities having at least one community woodlot. Most of these woodlots were established after the downfall of the military government in 1991. External organisations,

especially the regional Bureau of Agriculture, have been instrumental in facilitating the establishment of many woodlots. The most common allowed use of woodlots is to cut and collect grass for animal feed, roof material or other purposes. Most woodlots are managed at village level, while some are managed at a higher community (*tabia*) level. We find that community-managed woodlots tend to be larger than village-managed ones, benefits from woodlots are more common or greater in village-managed than community-managed woodlots and violations are more common in community-managed than village-managed woodlots. The average return per person-day invested in 1998 was higher for village woodlots than community woodlots. Villages are pursuing a more intensive management strategy than communities. Woodlots are in most cases protected by a guard paid in cash or kind.

Woodlots are most commonly planted with eucalyptus trees. We find that a woodlot of average-sized eucalyptus trees would be worth more than Ethiopian Birr (ETB)[1] 80 thousand. Thus, despite the limited current benefits that communities receive from woodlots, they are contributing substantially to community wealth. In addition, communities report few problems as a result of the establishment of woodlots.

We find evidence of an inverted U-shaped relationship between collective action for woodlot management and population density, where collective action is high at intermediate population density and low at both low and very high densities. Market access detracts from collective action for woodlot management, perhaps by increasing the opportunity cost of labour, increasing exit options, or increasing access of poachers. The involvement of external organisations in promoting woodlots has a negative effect on tree survival, suggesting that external organisations may not be achieving full participation of local communities in promoting woodlots.

Grazing lands

As with woodlots, grazing areas with use rules and regulations (restricted grazing areas) are widespread in the highlands of Tigray. Almost 90% of villages have at least one restricted grazing area. However, unlike woodlots, all restricted grazing areas are managed at the village level. More than one-half of the restricted grazing areas are used only for grazing by oxen. In addition to grazing animals, other allowed uses include cutting grass for feed or construction, fuelwood collection from dead trees and bee keeping. All villages reported significant regeneration of grazing lands due to the restricted uses.

Unlike woodlots, most of which were promoted by external organisations, most restricted grazing lands were promoted by the communities themselves, indicating the prevalence of local initiative for collective action in managing them. Contrary to the case with woodlots again, most restricted grazing lands were established prior to 1991. However, similar to woodlots, restricted grazing lands are usually protected by a hired

1. In 2002, US$ 1 = ETB 8.50.

guard. Most frequent violations reported in 1998 were letting animals graze where grazing is not allowed, and cutting grass for feed and construction without permission. Most violations were penalised.

We find that collective action for grazing land management is higher at intermediate population densities than at low or very high population densities, as for woodlots. Communities with higher social capital (as measured by the number of local organisations operating in the community) are more likely to contribute to collective action for grazing land management. Market access detracts from collective action for grazing land management, similar to the effect of market access on community woodlot management. Community heterogeneity in oxen ownership increases the likelihood of violations of use restrictions and regulations.

Conclusions and implications

Collective action for woodlot and grazing land management generally functions well in the highlands of Tigray. Community natural resource management can be an effective means of redressing natural resource degradation and increasing community wealth. Community natural resource management may be more effective and beneficial if conducted at the most local level, and if involvement of external organisations is demand driven and complementary to local initiatives. Collective action for natural resource management may also be more effective in areas with intermediate population pressure, low market access and higher social capital. In areas of greater market access, high population density or high wealth heterogeneity, private-oriented approaches to resource management may be more effective.

Comments *by Ephraim Nkonya*

Community woodlots are one of the responses to land and vegetative cover degradation. Local institutions and organisations are important in forging and enforcing collective action in addressing the land and vegetative cover depletion problem. The need to understand the factors that affect the development and effectiveness of local institutions and organisations in managing community woodlots is therefore apparent. This paper discusses collective action in management of community woodlots and grazing lands in the highlands of Tigray. The main contribution of the paper to the literature is its empirical findings. The paper is well written, as it provides hypotheses about the research questions, methods used for data collection and analysis and policy implications of the findings. Here are some comments that would further improve the paper.

i. The method used for hiring/electing officials who enforce restrictions on community resources may have impact; this may explain the weak enforcement at village level versus a stronger one at *tabia* level.
ii. On computing benefits from community resources, beekeeping was not included.

iii. Overall, benefits from woodlots are long-term, hence the need to compute returns to limiting resources (land, labour and capital) using a dynamic (temporal) model. This is amplified by the fact that the accumulated community wealth is not used in current period due to the restrictions.
iv. Market access is measured by only using distance from *woreda*. Other aspects of market access may be considered (e.g. distance to all-weather roads), and size of markets (population of nearest urban centre).
v. Survival rate of trees may be determined by type of tree planted. A dummy for dominant tree families in a given community may be added to the tobit model.
vi. The dependent variable of the regression on number of trees planted per hectare is truncated as only 88% of communities have woodlots. A tobit model would be appropriate in this case.

Interregional comparisons of agricultural production efficiency in the Ethiopian highlands

S. Ehui,[a] Zeleka Paulos,[a] Ayele Solomon,[a] S. Benin,[a] Berhanu Gebremedhin,[a] M. Jabbar[a] and J. Pender[b]

a. International Livestock Research Institute (ILRI), Ethiopia
b. International Food Policy Research Institute (IFPRI), USA

Given the diversity of agro-ecological zones in Ethiopia and variations in region-specific policies, one would assume that agriculture is fairly diverse regionally. The regional differentiation due to agro-ecology, policies and programmes leads one to expect variations in factor returns, allocations and productivity by region. This paper presents interregional comparisons of agricultural production efficiency in the Ethiopian highlands based on data from extensive community, household and plot surveys conducted for the production year 1999–2000 in three regions of Ethiopia, namely, Amhara, Oromiya and Tigray.

Total factor productivity (TFP), which measures levels of output for a given level of total inputs, is usually associated with more efficient allocation of a given level and quality of inputs. The efficiency differential methodology used in this paper helps to provide an answer to the following question: How much extra output is produced in region *i* compared to region *j* after accounting for differences in input quantities used in each region? As an alternative, the following question can be asked on the dual side. After accounting for differences in output levels and input prices, how much lower are total costs in region *i* compared with region *j*? The analysis therefore allows us to determine which regions have higher or lower efficiency levels.

Making use of the Tornqvist–Theil index, productivity estimates are calculated using bilateral comparisons of productivity between an arbitrarily chosen region—Amhara—and the other two regions. Prior to analysing productivity differentials among regions, the variations in total output, input and factor shares are examined. Factor shares tend to vary across regions. However, the shares of labour and oxen draft power are highest among inputs in all regions, showing that they are the most important inputs and, more importantly, confirming the labour intensive nature of farming practices across all the three regions. Of the three regions, the share of human and oxen labour is highest in Tigray.

The share of seeds is more or less constant at about 5–11% across the three regions. With an 11% input share, seed use is relatively higher in Amhara as most of the region's crops are annuals. Moreover, Amhara farmers tend to make more use of seeds than chemical inputs, probably due to limitations in supply and distribution of chemical inputs, and credit constraints, which may lower investment in fertilisers. This is supported by results from Amhara that local credit is associated with increases in the use of

seed only, although external credit was found to be associated with increased use of all inputs. Comparatively, perennials are more common in Oromiya, reducing the frequency in the use of seeds.

The use of chemical inputs is greatest in Oromiya (12%), as it is the region with the most cash crops. As the return from cash crops is higher than that from annual crops, the higher purchasing power enables farmers to better afford the purchase of chemical inputs. By contrast, the share of chemical inputs is lowest in Tigray (3%) due to the region's erratic rainfall conditions, which places limitations on fertiliser use, as chemical inputs generally require ample water resources. As a result, the return from chemical inputs is low, further discouraging the use of chemical inputs. This supports econometric results from Tigray, which indicate that the marginal return to chemical fertilisers is lower than those for low input technologies and other livelihood strategies such as livestock.

Purchased feed has the lowest share in all regions with the exception of Oromiya. With a 10% share in total inputs, purchased feed is comparatively higher in Oromiya, perhaps as a result of higher herd size per household, but also likely due to the higher purchasing power of cash crop farmers and the relatively greater number of urban centres, which enhances access to purchased feed.

By computing the differences in TFP for the regions under study, we are able to compare the relative efficiencies among these regions revealing spatial differences. We convert the differences in TFP to index levels, with Amhara taken as the reference region. Oromiya and Tigray are found to be 20 and 41% less efficient than Amhara when considering crop output alone, and are 15 and 36% less efficient when accounting for both crop and livestock products. Thus, Amhara can probably better survive unexpected increases in the cost of production than Tigray and Oromiya. However, it is worth noting that these productivities are measured for a single production season. It is not known from this analysis how productivity in any of the study regions has been changing. Therefore, we cannot draw inferences about whether or not the Amhara region can continue to maintain its comparative advantage. Such conclusions will have to be measured based on intertemporal productivity data for additional years.

Having observed the disparities in TFP across regions, an effort was made to examine the sources of productivity variations and see the extent to which differences in output were a result of differences in productivity or factor inputs. The contribution of total input variation to output differs for Oromiya and Tigray. In Oromiya, variation in total inputs accounted for 79% of the variation in output. The residual of 21%, which is the share of output change not accounted for by changes in input, is attributed to differences in productivity. Land differences were the largest contributor to output variation in Oromiya (35%) followed by labour and oxen draft power (20%), with seeds, chemical inputs and feed contributing 10, 7 and 7%, respectively. On the other hand, in Tigray, inputs accounted for –300% of the variation in output while TFP was a major source of output change, accounting for 400% of the variation in output. The inputs that contributed more significantly to output variation in Tigray were land (36%), labour and oxen power (–318%), while feed, seeds, and chemical inputs contributed –18, 9 and –9%, respectively.

Policies and programmes can alter the efficiency differentials between regions. Livestock play a significant role in affecting efficiency across regions. Thus, policies that induce livestock production and improve livestock management practices will be essential. The advantages of doing so go beyond the contribution of livestock to increasing crop production, by providing farmers with additional income earned directly from livestock. Credit and extension services should be supported as they play a vital role in enhancing crop and livestock output, but should be geared to addressing the concerns unique to each specific region. In Amhara and Oromiya, extension services should focus on improving methods in the application of fertilisers and improved seeds, land conservation and land and livestock management practices, while credit would be useful for increasing use of inputs such as improved seeds and fertilisers. Given the relatively lower levels of rainfall in Tigray, it is beneficial for extension and credit services to target livestock development and improving livestock management, in addition to supporting land conservation.

Comments *by Stein Holden*

This is an interesting paper making a comparison of the competitiveness of agriculture in different regions in Ethiopia. The paper focuses on production efficiency. The concept of efficiency as used by economists may sometimes be confusing to non-economists and even to economists themselves. Usually, production efficiency is assumed to be achieved when production is on the production possibilities frontier (PPF). Production inefficiency implies that production is somewhere inside the PPF curve. This paper seems to ignore this requirement as nothing is done to identify the PPF for the different regions. It is highly unlikely that it is identical across regions, or even across plots, farms, peasant associations (PAs), or *woredas* within regions.

Theodore Schultz, who won the Nobel Prize in 1979 for his work, found that small farmers are 'poor but efficient, that it is not due to their inefficient behaviour that they are poor but because of the constraints they face in their environments'. In this paper, it was found that small farmers in Tigray are much less efficient than farmers in Amhara and Oromiya regions, but differences in agro-climatic conditions were not controlled for.

Using TFP as a measure of efficiency is a good approach and so is the approach to identify a TFP-index. The paper should, however, be modified and built on more realistic assumptions than zero transaction costs, perfect markets, uniform land quality and uniform climate. There are aggregation problems when transaction costs and asymmetric information cause prices to differ systematically across farms, PAs, *woredas* and regions. Wide price bands cause non-participation in markets and selling prices to be much lower than buying prices. Use of uniform prices cause identification of 'inefficiency' where there is rational and efficient decision-making when transaction costs are pervasive. With proper control for such factors, the approach may be used to, for example, assess the inefficiency impacts of policy distortions, alternative tenure

contracts etc. Interesting policy issues include: to what extent are transaction costs reducible and to what extent can the PPF be pushed out through technological change?

The role of micro-credit in addressing land degradation in Uganda

G. Akello

Ministry of Gender, Labour and Social Development (Entandikwa), Uganda

Introduction

When microfinance interventions were introduced in Uganda in the early 1990s, borrowing patterns for micro-enterprises followed the pattern of economic activity in the country. Over 80% of microfinance clients borrowed money for agricultural activities; crop farming as well as some livestock raising. Entandikwa returns indicate that the majority of clients used the funds in projects related to agriculture. Similarly, over three-fourths of the clients of the Poverty Alleviation Project (PAP) did the same. It is therefore very important to look into the relationship between land degradation, household poverty eradication and microfinance.

Land degradation in Uganda

Many parts of Uganda face serious land degradation problems. The worst affected areas include the over-utilised areas of Kotido and Moroto districts of Karamoja and Isingiro, Nyabushozi and Kazo counties of Mbarara District, heavily-utilised areas of Okoro and Padyere counties of Nebbi, Kabula county of Rakai district, Bukoto in Masaka, Bulamogi, Busiki and Kigulu in Iganga District to Bunyaruguru county in Bushenyi District. According to NEMA's 2000/2001 report, land degradation is caused by high population growth rates, poor methods of cultivation, deforestation, bush burning and overgrazing. Key land degradation issues in Uganda include: escalating soil erosion, decreasing soil fertility, agrochemical pollution and desertification. Among the districts faced with encroaching desertification are Moroto, Kotido, Nakasongola and (Kakuuto county in) Rakai.

The International Food Policy Research Institute (IFPRI) researchers in Uganda have noted that soil degradation problems, such as erosion and nutrient depletion are of growing concern in the country. IFPRI further notes that soil fertility depletion, cultivation of marginal lands, continuous cropping, poor soil and crop management practices and government policies that fail to help smallholder farmers are causing declining productivity in Uganda.

Microfinance and the challenge of improving Uganda's soil fertility

The nature of the land degradation challenge that microfinance clients face, by the farming systems in the country, is summarised in Table 1. Knowledge of the particular land degradation challenge in each district helps place farmer client precisely. In this way we can meaningfully plan any appropriate interventions.

Table 1. *Land degradation challenges in Uganda by farming systems.*

Farming system	Area	Land degradation challenges
Intensive banana–coffee system	Shores north of Lake Victoria, Mukono, south-east Mubende, southern Luwero, Ssese Islands, Kampala and Entebbe, Jinja, Iganga, Mpigi, south Kamuli and eastern Masaka and Rakai	Perennial crops and intercropping, though advantageous, has not stopped soil degradation due to continuous use of small plots that do not benefit from restorative measures; mailo land tenure system
Western banana–coffee–cattle	Bushenyi, Kabale, Rukungiri and parts of Mbarara	Highly fragmented land holdings due to population pressure; alarming deforestation, poor farming practices and steep slopes resulting in soil erosion; customary land tenure
Kigezi Afro-montane (southwest highlands)	High altitude areas in Kabale and Kisoro as well as the northern slopes of the Muhavura Mts	Soil fertility is dwindling fast; land fragmentation increasing due to population pressure; contour bunding increasingly eroded for more farmland; therefore, increased soil erosion leading to land slides
Northern and eastern cereal–cotton–cattle	Apac, Gulu, Kumi, Tororo, Soroti and some parts of Mbale	High wind and water erosion; bunding and fallowing virtually abandoned
West Nile cereal–cassava–tobacco	Arua, Nebbi, Moyo, Adjumani, Yumbe	Declining soil fertility; increased soil erosion

Source: http://easd.org.za/Soe/Uganda/CHAP3.htm

The majority of Ugandan farmers depend on what they believe to be the natural fertility of the land. Occasionally they fallow the land and, even less occasionally, use organic manure to revamp soil fertility. Leaving land uncultivated for a number of years so that it regains its fertility is not an option for densely populated districts like Mbale, Kisoro, Kabale, Rukungiri, Bundibugyo, Kasese or Bushenyi. In these districts, where lands are also prone to soil erosion, available land simply has to be used continually as the population demand is high (Table 2). Yet even in these districts, there is little evidence to suggest that smallholder farmers prioritise fertiliser use as a way to spend their borrowed microfinance. The amount of money farmers receive as start-up capital is so precious to them that their most immediate concern is to cultivate and plant commercial crops. None of the Entandikwa project reports indicate the purchase of fertiliser as an essential element in the project. Yet restoring soil nitrogen and phosphorous is a major priority not only for sustained productivity, but also for the rehabilitation of eroded and damaged soils.

Table 2. *Population pressure on land.*

District	People/km^2	Area affected by soil erosion (%)
Mbale	282	80
Kisoro	279	85
Kabale	250	90
Mpigi	204	25
Masaka	151	50
Rukungiri	150	30
Bushenyi	149	20

Conclusion

Poverty eradication through microfinance is still a new concept, but the number of clients in this area will grow with more microfinance operations in the country. These are unwitting victims of land degradation. They are, therefore, the most natural partners in the fight against land degradation. It is clear that interventions that meant to garner the support of smallholder farmers against land degradation must take into consideration the varying nature of land degradation and its causes in the country.

Policy implications

The following policies are implied in this paper:

1. A rural finance policy with the following elements:
   - constituent elements of farmers' micro-credit package to cater for improved agricultural technologies including seed, pesticides and fertiliser
   - regulatory oversight so that poverty eradication through rural finance does not lead to pauperisation
   - appropriate repayment mechanisms in relation to farm activity *vis-à-vis* non-farm activity
   - a land use and management fund
   - soil conservation programmes
   - rural electrification sourced from solar or water as appropriate.
2. A soil conservation policy that is tied to rural finance access.
3. A land use policy that is tied to rural finance access.

Adoption of any of these policies will, needless to say, require prior critical study, analysis and consensus building. Once adopted, such policies should be backed by effective laws that are rigorously implemented at local and central government levels.

Dynamics of maize market integration in post-liberalised Uganda

S.Rashid

International Food Policy Research Institute (IFPRI), USA

The nature and extent of agricultural market integration influences decision making of agricultural households in many ways. Of particular significance are the decisions regarding technology adoption, farming practices and overall management of natural resources. Farm households are not likely to adopt a production technology, even if it is otherwise considered the best, unless a well-functioning market for the product exists to make the technology viable. As a result, in the geographic regions that lack market integration, in addition to facing limited livelihood options, farmers are often observed to choose sub-optimal technology. In addition to substantiating these contentions, cross-country empirical studies—such as studies of optimal famine relief policies, effective implementation of price stabilisation policies and the determinants of poverty dynamics—provide evidence that establishes the critical linkage between market integration and human well-being in agrarian societies. It is perhaps one of the main reasons why the term market access surfaced so dominantly throughout this regional policy conference. In line with this general theme, this paper provides empirical evidence on the dynamics of maize market integration in post-liberalised Uganda.

While there is a general consensus that market integration refers to the spatial flow of goods and information, a unique definition that captures all aspects of the concept with testable implications remains elusive. As a result, empirical methods for spatial market integration analysis vary widely depending on underlying economic and statistical assumptions. This paper uses a method developed within Johansen's multivariate co-integration framework and which analyses the extent of integration among a set of spatially separated markets. Empirically, the methodology is carried out in two broad steps. The first step involves identification of the markets that share a common stochastic trend or, equivalently, belong to the same economic markets; and the second step assesses the relative importance of each of the markets in long run price formation. The underlying idea is that, for a given set of market locations, not all locations belong to the same economic market, and among those that do belong to the same market, some will be more integrated than the others. Thus, these estimates can help policy makers in targeting geographic locations in order to set up information dissemination centres or to implement any other price stabilisation interventions.

Data for this study are derived mainly from two sources: i) Famine Early Warning System Network (FEWS-Net), which collected and analysed weekly price data from January 1993 to January 1999; and ii) Foodnet of the International Institute of Tropical Agriculture (IITA), which, at least in terms of data compilation, replaced FEWS-Net data collection activities in 1999. In addition to collecting weekly price data, Foodnet also

disseminates price information in selected districts through radio broadcasting. From the 1st week of 1993 to the 40th week of 1994, the time series was continuous and long enough to be able to carry out the analysis in the following eight districts: Kampala, Jinja, Masaka, Gulu, Arua, Mbarara, Hoima and Mbale. In terms of the length of the time series, the first 92 weeks of FEWS-Net data matches the Foodnet data for the selected districts and, thus, enable a valid comparative analysis between the two periods. Given the history of economic reforms in the country, analysing data for these two sub-periods also helps understand how the dynamics of market integration have changed since the early years of liberalisation.

Based on the empirical results, three broad conclusions are drawn. First, the study finds that compared to the early years of liberalisation, the extent of integration in Ugandan maize markets has improved in recent years. Some district markets, such as Masaka and Mbarara, which did not integrate with the dominant central markets in the early 1990s, became strongly integrated in recent years. In a broader sense, this result supports the fact that the impacts of market liberalisation should be evaluated in a longer-term context, not during the immediate aftermath. Given that Masaka and Mbarara had relatively good road networks in the early 1990s, non-integration of these markets also suggest that access to infrastructure is not a sufficient condition for market integration, at least in the early years of liberalisation when marketing networks are in their infancy stages and the institutions that ensure healthy market exchange are yet to emerge.

Second, though not surprising given the political realities, northern districts continue to lack integration with the central markets. Two of the northern districts, Arua and Gulu, show disturbing trends. When compared with the price trend in Kampala, Arua shows a trend reversal during most of 2000 and 2001. Furthermore, the null hypothesis that Gulu shared a common trend with the central markets was rejected at 5% level of significance for both sub-periods. In the context of market connectedness and poverty, this finding is very consistent with studies on regional poverty in Uganda and elsewhere in Africa. It is in full conformity with other studies on the dynamics of poverty in Uganda in the 1990s, that demonstrate that while the overall poverty situation in Uganda improved in the 1990s, the absolute poverty in the northern region increased in some cases. The continued non-integration of northern district markets may be due to continued state of insurgencies in the region. However, these results, particularly the trend reversal in Kampala–Arua prices, hold clear policy implications for regional trade. It seems to be common knowledge in Uganda that the traders in the northern districts continuously engage in trade with neighbouring country traders. If such trading is viable, despite being illegal and, consequently, involving high transaction costs, it warrants serious consideration for devising policies for regional trade. If implemented effectively, such trade policy can enhance market integration as well as improve welfare of the producers who have to settle for lower prices due to low domestic market demand.

Finally, estimated common factor coefficients suggest that the major consumption markets, such as Kampala and Jinja, are the most influential factors in long run maize price formation in the country. Furthermore, the coefficients are found to be well correlated with district level production statistics. Districts with larger production of

maize seem to have larger common factor coefficients. For example, analysis of the 2000–01 data suggest that Iganga and Lira, the largest and second largest maize growing districts in the country, rank third and fourth, respectively, in terms of their importance in price formation. From a policy point of view, this set of results can be of significant importance in designing targeted market intervention, such as implementing *ceiling* and *floor* prices for market stabilisation purposes. The unexpected decrease in maize prices in recent months in Uganda, which received substantial media and political attention, reinforces the importance of initiating policy discussions in order to determine whether such price stabilisation strategies are needed for the country.

From a policy standpoint, the bottom line questions are: what are the factors that contributed to improve market integration in Uganda in recent years? Is it worth investing in market information system, such as Foodnet, for the role that it plays in improving market integration? Adequately answering these questions was beyond the scope of this study, but some cautious conclusions can be drawn by corroborating our results with some additional information. Although not derived through robust statistical analysis, this study finds a clear relationship between the information flow index for Foodnet, constructed by the Spatial Analysis Research Group at the International Food Policy Research Institute (IFPRI), and the significance of district markets in price formation. Specifically, high common factor coefficients are found to be positively correlated with the information flow index, measured in terms of length, frequency, language match and other attributes of the Foodnet radio broadcasting. Also, a recent IFPRI household survey shows that the radio is the main source for market price information of the rural household in Uganda. I do not dare to argue that this evidence is enough to establish a clear cause and effect relationship between information flow and market integration. There can be a number of other factors (such as infrastructure, trade networks, political stability) that have contributed to the improvement in the spatial integration of Ugandan maize markets. Nevertheless, given that annual operational cost of Foodnet is only US$ 60,000, which is a small fraction of overhead or administrative costs of any development project, it is perhaps safe to advocate that Foodnet-type programmes should be extended in other countries in the regions.

Comments *by Dick Sserunkuuma*

Several reasons have been given to justify market integration studies, but the one I find most appealing and related to the rationale for identifying different pathways of development, and which is guiding targeted policy intervention, is that market integration analysis can be used for geographic targeting of market and price information dissemination centres to avoid costly and indiscriminate dissemination of information to markets between which arbitrage cannot take place. So just like the studies on pathways of development in the East African highlands, I find this study very well motivated.

Using weekly price data from two sources, the study found that the extent of Uganda's maize market integration has improved in recent years compared to the early 1990s, i.e. several markets (Kampala, Jinja, Masaka, Iganga, Mbarara, Mbale and Lira) became more

integrated. A recent IFPRI study is quoted in support of this finding, which shows that the majority of agricultural traders started their businesses within the past 7–8 years, and that the business network, defined as the relationship of trust among traders across various regions, is very limited.

The question is how long does it take to build this relationship of trust or network? This lack of trust among traders, farmers, consumers and moneylenders is one of the reasons why Uganda's economy (and probably the economies for other African countries) is cash based, meaning that most people use their own cash to start businesses (either from own savings or with the help of relatives and friends) and, likewise, consumers must purchase with cash before they can consume. Because of this, many local entrepreneurs have failed in business because they cannot compete with foreigners who have preferential access to credit from their countries. Is there no room for policy to address this problem of lack of trust?

The study also found that northern districts of Arua and Gulu show weak or no integration with the dominant markets in the central region (Kampala and Jinja). The explanation of insecurity and possibly poor infrastructure are appealing, but what I find more intriguing is the possibility that the Arua market is trading with neighbouring countries, meaning that it is more integrated with cross-border markets than with markets within Uganda. Can this be used to justify regional market studies to show which cross-border markets are integrated as a way of advocating for the legalisation of informal cross-border trade?

The study attempts to link poverty to lack of market connectedness by arguing that increased market integration contributed to poverty reduction between 1992 and 1996, except for northern Uganda districts where poverty increased during this period because the markets in these areas were not connected to markets in the rest of the country. There is no enough evidence in the paper to make this conclusion. However, if it is found to be true through further research, this shows how our efforts to eradicate poverty via agricultural modernisation are doomed to fail as long as farmers remain disconnected from the markets.

Finally, the study shows that the price information collection and dissemination effort of Foodnet has contributed much to the recent improvement in market integration in Uganda, and is a worthwhile domain for public investment.

Motivating smallholder investment in sustainable land management: Emerging roles for NGOs and CBOs in Uganda

P. Jagger and J. Pender

International Food Policy Research Institute (IFPRI), USA

Under the Plan for Modernisation of Agriculture (PMA), the Government of Uganda is decentralising many government services that have traditionally been responsible for promoting sustainable land management. One of the main goals of the PMA is that all activities related to agricultural production, agricultural processing, trading and supply of inputs, and the import/export of agricultural produce will eventually be carried out by the private sector. Because the private sector is underdeveloped in many sectors and regions, non-governmental organisations (NGOs), and community-based organisations (CBOs) are being called upon to take the lead in providing these and other services in the short to medium-term. For example, the National Agricultural Advisory Service (NAADS), one of the five central initiatives of the PMA will rely on NGOs to provide demand-driven fee-for-service extension services to smallholders within three to five years.

The objectives of this research are to characterise government programmes, NGOs and CBOs in communities, and understand the determinants of their presence; to characterise and understand the determinants of household level involvement in organisations; and to consider the role that the presence of a programme or organisation in a community and household level involvement in an organisation plays in the adoption of land management technologies. The analysis is based upon data from a survey of 107 communities conducted in 1999/2000, and a household level survey of 451 households conducted in 2000/2001. The random sample of communities surveyed was stratified by agricultural potential, market access and population density. Approximately four households were randomly selected from within each community.

Our analysis of programmes and organisations functioning at the community level between 1990 and 1999 indicates that government programmes were better distributed throughout Uganda than NGOs or CBOs, and that in general government programmes focused on poorer communities. Approximately half of the 107 communities in our sample had government programmes, NGOs or CBOs that focused on what we refer to as the proximate causes of land degradation (i.e. provided agriculture or environment related information and services), and in general these communities were in the high potential bimodal rainfall areas (near Lake Victoria). We hypothesise that households will be more likely to adopt land management technologies where there is a programme or organisation focused on the proximate causes of land degradation present in their

community. There are few communities in the highland areas that have a programme or organisation with a main focus on agriculture or the environment despite the fact that land degradation is a serious problem in these regions. Higher average numbers of agriculture and environment programmes and organisations are also found in communities with good market access and relatively high population densities.

We also considered the distribution of other types of programmes and organisations (i.e. those focused on alleviating population pressure; providing, improving or maintaining basic infrastructure and services (i.e. health, education, water etc.); providing credit; reducing poverty; and providing basic community services) among the communities in our sample. We hypothesise that these types of programmes and organisations may indirectly affect the adoption of land management technologies. For example, if a household receives credit from an NGO that allows it to address some immediate need, the household may be able to adopt a longer-term perspective on investments such as tree planting that lead to improved land management. We found high average numbers of programmes and organisations dealing with infrastructure in the southwest highlands. In addition, programmes and organisations dealing with poverty and community services were well represented in the southwest highlands. In contrast, the eastern highlands had very few communities with programmes and organisations addressing poverty, and none with programmes or organisations that provided community services.

The distribution of government programmes, NGOs and CBOs throughout the country, as well as the current focus of NGOs and CBOs has implications for how smooth and equitable the devolution of service provision will be. The question of whether or not the government should be providing incentives for NGOs and CBOs to locate or evolve in regions of the country that are currently lacking an adequate NGO and CBO presence should be considered.

Data on household level involvement in programmes and organisations revealed somewhat different trends, possibly due to differences in how community and household respondents interpreted 'involvement' in programmes or organisations. For example, communities often report involvement in government infrastructure projects (e.g. providing labour services in road construction), while households may interpret this as 'employment' but not 'involvement'. In general, respondents reported very little household level involvement in government programmes and only moderate levels of involvement in NGOs. For example, in the unimodal and bimodal high rainfall areas approximately 20% of households reported involvement in NGOs. At least 75% of all households reported involvement in CBOs with the exception of the eastern highlands where less then 5% of households were involved in CBOs. Approximately 30% of households were involved in organisations focused on agriculture and the environment. We found that households reported very high levels of involvement in credit and community service oriented NGOs and CBOs, particularly in the southwest highlands. Econometric analysis of the determinants of household level involvement in NGOs and CBOs indicated that female headed households and households with higher numbers of female members were more likely to be involved in organisations. We also found that social capital was an important indicator of household level involvement in organisations: if the household head was a member of a dominant ethnic group, or if the spouse of the

household head was born in the village, involvement in an organisation was more likely. Additionally, smaller land holdings were associated with involvement in agriculture or environment related organisations.

In the context of household involvement in community service oriented organisations, we can consider this involvement a proxy for strong social capital. It may be that much of the technology transfer that is taking place is occurring through these institutionalised social networks. However, we note that the community may not be in all cases the appropriate unit of observation to understand social networks that promote the exchange of information. It may be that information on technologies is being exchanged across communities according to family networks, inter-community networks or groups, or other units of social organisation. More research is needed to understand the sociological aspects of technology diffusion as it relates to the adoption of land management technologies.

In general communities perceived that programmes and organisations focused on agriculture and the environment were having a positive impact on land management, crop and livestock production. To validate these perceptions we used a two-stage probit model to explore whether or not the presence of an organisation in a community and/or household level involvement in an organisation was related to the adoption of various land management technologies in 2000. Our results indicate that presence of an agriculture or environment focused programme or organisation in the community had a positive effect on the adoption of only one of the five technologies we considered. Also, we found that household involvement in agriculture or environment focused organisations had a negative effect for one of the technologies we considered. These findings are of limited encouragement regarding the effect of agriculture or environment focused programmes and organisations being present in a community, and/or household level involvement in such a programme.

A possible explanation for our weak results regarding the effect of agriculture/environment focused programmes and organisations on the adoption of land management technologies is that smallholders may be receiving training on land management, but may not actually be adopting the promoted technologies. This may be due to the limited profitability of investing in some land management technologies. If it is determined that agriculture and environment related NGOs and CBOs are having little impact on the actual adoption of land management technologies, there may be a need to evaluate the role and effectiveness of these organisations, as well as the relative profitability of the technologies promoted.

More promising are our findings on the effect of household involvement in credit, poverty alleviation, and in some cases community service oriented organisations on the adoption of land management technologies in 2000. The impact of household involvement in credit related organisations in particular appears to offer promising opportunities for improving land management. Our findings suggest that community-based credit organisations should be promoted as a means for improving the adoption of land management technologies. However, we emphasise that linkages between programmes and organisations focused on credit, poverty alleviation and other activities that are not directly related to land management, and the adoption of land management technologies

is indirect and likely related to the alleviation of immediate stresses that households face, and/or the building of social networks that facilitate the transfer of information on technology adoption.

Comments *by Dick Sserunkuuma*

The paper is too long and one easily gets lost in the process of reading it. The authors need to find a way of shortening and focusing it to make it more reader friendly.

The paper points out that like the case with many other developing countries, the central government of Uganda is in the process of devolving from the provision of many services including those directly related to agriculture and the environment to non-government organisations (NGOs), community-based organisations (CBOs), local government and the private sector. At the same time, the condition of natural resources including land is deteriorating and it is important to ask whether the NGOs, CBOs etc. have demonstrated the capacity to reverse the trend of declining natural resource conditions and oversee a sustainable use of Uganda's natural resource base.

The first thing that strikes me is that, in the mid 1990s, there were over 1000 NGOs registered in Uganda, and unless the activities of these are harmonised, conflicts are bound to arise among the NGOs themselves, which will inturn affect how well they do the job that the government wants them to do. There is potential for giving farmers conflicting messages about which management practices to adopt, and as a result, may undermine adoption.

The paper does a good job categorising organisations according to main areas of focus and directly or indirectly links this to land management. The conceptual framework guiding the econometric analysis is reasonable, but the econometric models have so many variables on the right hand side, many of which may be related or jointly determined with what the models attempt to explain. More work is certainly needed on the modelling.

The major finding is that the presence of programmes or organisations in a community, and household involvement in programmes or organisations, do not provide strong evidence that programmes and organisations are directly affecting the adoption of land management technologies. The results show that the presence of an organisation or programme focusing on agriculture or environment in a community has a positive effect on the use of crop residues only, but household involvement in an agriculture or environment focused programme was associated with lower likelihood of adopting crop residues. This is quite confusing and is not well explained in the paper. Some more analysis is needed to understand exactly what this means. In addition, the possibility that this negative effect of agriculture or environment focused programme on land management is a result of conflicting messages from the organisations should be investigated.

The other result that is not very clear is whether these farmers are applying crop residues deliberately to improve soil fertility or if they are doing it subconsciously with their main aim being crop residues disposal. Either way, if programmes and organisations are not affecting land management, then it means some groundwork needs to be done to

mainstream environment issues into the activities of the NGOs and CBOs in Uganda before the government can entrust them with the responsibility of delivering services related to agriculture and the environment.

There are some encouraging results, however, which show that households involved in credit-related programmes are more likely to adopt improved fallow and woodlot technologies. Credit organisations were hypothesised to indirectly affect land management but they seem to have a bigger impact than organisations that are expected to address land management issues directly. This shows that the farmers' main concern may really not be land management, but rather issues that directly impact on their lives such as lack of cash to pay for food or emergency needs, which induce them to join credit organisations. In fact, more households are involved in credit and community service organisations than in agriculture and environment focused ones. It may, therefore, be more effective to work with organisations that do not directly address environmental issues (such as credit or community service organisations) and mainstream such issues into their activities to stealthily improve land management rather than focusing on or promoting organisations that directly address land management.

Land tenure systems and their implication for food security and sustainable development in Africa

J. Dione

United Nations Economic Commission for Africa (UNECA), Ethiopia

The changing economic environment associated with structural adjustment programmes and globalisation has led to a general trend towards privatisation of land and the collapse of collective structures in agriculture. By the same token, there is a move towards reliance on the market as a means for reallocation of agricultural land. It is increasingly argued that land must be privatised or that people should have exclusive and secure rights on their land. An important argument in favour of land privatisation is that farmland held under exclusive and secure land rights (e.g. titled land) is more productive than farmland held under other forms of rights (e.g. communal lands). If true, then reforms leading to titled lands or individualised land rights may increase food security through improvement of production efficiency and access to food. The argument goes further to claim that present forms of land tenure systems do not provide sufficient security to support investment, to facilitate mobility of resources needed in a dynamic economy or to facilitate access by poor farmers to participate in the development process.

It also appears that problems of tenure and access to land in many places have contributed to degradation of land and poor management of natural resources. There is ample evidence of continued pervasive rural poverty and hunger related to unproductive agrarian structures. Many studies have shown that the under-utilisation of land resources by some and the intensive degrading use of marginal lands by multitudes of land-poor farmers still characterise contemporary agrarian structures in developing countries. The main conclusion of these studies is that the leading cause of rural poverty is the lack of sufficient access to and low productivity of land.

Some argue, however, that the hypothesised greater production efficiency gain through land privatisation may be an illusion if other public policies such as provision of rural infrastructure, promotion of market efficiency, dissemination of information about new technologies and access to credit are not in place. This debate may continue so long as there is insufficient empirical evidence. Therefore, African countries are confronted with many challenges while searching for ways to integrate their predominantly customary/communal land tenure systems into national economies in ways that are compatible with the ongoing economic reforms and the objective of increasing food security and sustainable development.

Food security and land tenure have both been subjects of many studies. However, very little has been done on the complex linkage between the two. Much of the food

security issues deal with land as a resource, and most of the land tenure literature gives little reflection to how the nature of the land tenure system may affect the state of the food security. For example, it has been noted that when families believe that the land tenure system is unfavourable to them, they are reluctant to invest in good agricultural practices, such as soil and water conservation and management. Also, access to sufficient food enables people to increase their productivity and their disposable incomes. Food insecurity may also have future distributional consequences on land. A landowner who is faced with the uncertainty of future consumption may ration his/her current consumption for more future consumption in the short run. However under a chronic hunger situation, the farmer may not have any other option than to sell his/her land in order to satisfy current consumption needs.

To achieve sustainable food security, policy makers urgently need knowledge on how to prevent excessive use of natural resources, and reduce food insecurity and rural poverty. Although it is believed that no single land use and acquisition strategy provides sufficient grounds for food security, it is, however, very important to understand the impact of different land tenure systems on food security and sustainable development. This will enable African governments to identify which combination of land holding systems to implement in order to maximise food production and increase food security, while at the same time protecting their natural resource base.

The provision of better information on the relative efficiency of farm lands in Africa under different tenure systems would provide a better indication of how tenure systems affect resources use and thereby the overall productivity of farming operations, leading to greater food security and more sustainable development. The objective of the proposed study is to improve the understanding of the structure, operation and dynamics of agrarian systems in Africa, and simultaneously assess quantitatively their effects on food security and the efficiency of natural resource management.

Comments *by Simeon Ehui*

The proposal benefited from many comments and should take advantage of the land tenure experts at the conference. Specifically, the paper should look into:

- Narrowing down the goals: The study aims at examining sustainable development, but what does this really mean? It is too broad a topic and should therefore be more focused.
- Efficiency of tenure systems: The usual practice is to look at how land tenure systems affect productivity. However, the paper should consider looking at how productivity impacts land tenure systems.

This last point is more of a suggestion. Rather than conducting the study *per se*, why not convene a conference on land tenure to find out what is known regarding this topic and what is not known. Then get other institutions that have comparative advantage in conducting surveys etc. to implement the study.

Macro-economic and sectoral policies and their influence on land use and management: Some lessons from southern Africa

I. Minde

Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA), Uganda

Background

This paper is based on a project entitled 'Macro-economic and sectoral policies and their influence on livelihood strategies of households in the miombo woodlands' implemented in five countries in southern Africa by the Centre for International Forestry Research (CIFOR) and sponsored by the European Union. The countries are Malawi, Mozambique, Tanzania, Zambia and Zimbabwe. The project began in late 1996. While based at the Agricultural Policy Research Unit, Bunda, University of Malawi, I was involved in designing the conceptual framework for the project and also in leading one of the first batch of studies in this area. Since then, I have kept my interest in the project through reading some of the research results from the research briefs from the project office in Harare, Zimbabwe, where the regional CIFOR co-ordinator for eastern and southern Africa is based.

The overall development objective of the project is to improve the productivity of the forestry sector and, hence, its role in the welfare of the people of the miombo ecozone through sustainable management and use of woodland resources. The focus of the research is to increase the understanding of the management and use of the miombo woodlands and how different policies influence man–woodland interaction and provide new information to guide sustainable management of the woodlands.

The main objective of this paper is to share the conceptual framework and some hypotheses and findings on completed studies from the project. To a large extent, the project deals with how rural households manage and use land given the pressures and opportunities from forces emanating from various policies. The project on Policies for sustainable land management in the East African highlands, which is the theme of this conference, has a number of things in common with the southern African one. It is therefore possible to gain some insights from the miombo woodlands project that could help contribute to mapping future directions for the project on Policies for sustainable land management in the East African highlands.

Conceptual framework of the miombo woodlands project

As population grows simultaneously with economic development, the total growth of the latter is impinged upon, among others, by three different kinds of constraints: limited land area, non renewable resources such as fossil fuel and ability of the environment to absorb the pollution effects of economic activity. The proportions of cropping and grazing land have expanded too, along with expanding human population to the detriment of resources such as forests. Although agricultural expansion has in some cases encroached in areas unsuitable for this purpose (forests), the same area could still be important for watershed, soil and biodiversity conservation.

The inter-relationships between macro-economic and sectoral policies such as those on food, agriculture, natural resources (forests) and people in developing countries are very complex. Yet, understanding these inter-relationships is paramount in influencing the process, pace and magnitude of development necessary for enhancing people's welfare.

The thrust of the studies in this project was to understand how macro-economic policies and other factors influence this complex interactive process. The project underscores the existence of strong linkages between macro-economic policies (such as monetary, fiscal, exchange rate, trade and employment) and sectoral policies (such as land, agriculture, forestry, population and the environment). The macro policies influence the sectors through tools and instruments such as market, tariffs, subsidies, taxes and transfers (Figure 1).

The political and socio-economic goals of many governments also shape the macro-economic policies designed to pursue them. For example, on becoming independent, the project countries pursued different political directions; Mozambique leaned towards Marxist policies, Tanzania had a home grown socialist (ujamaa) policy, Malawi was more on a capitalistic path and Zimbabwe talked of socialism, but practised capitalism and left the private sector intact. These political and economic orientations inevitably influence the way business is done across the different sectors.

Macro-economic policies are defined at the planning level of the economy. In order to operationalise these broad policies, consultations are made with all sectors of the economy, both at national and other lower administrative levels. An institutional framework exists and links both macro and meso levels in designing means and operationalisation of the macro-economic policies. There is some legislation (a set of rules, regulations, acts and ordinances etc.) that guides the conduct of business in all the sectors. Each sector then interprets the broad goals in its own operational environment and this shapes the sector's goals/objectives, strategies and activities, all of which constitute sectoral policies and action plans. The various sectors as well as households get their inputs (capital, labour and land) from the markets (meso level). They off-load their production of goods and services at the market place.

Structural Adjustment Programmes (SAPs) are pertinent in this conceptual framework and their entry is at the macro level. They are actually part of broad-based economic policies. These are policies that involve redressing and repositioning some of

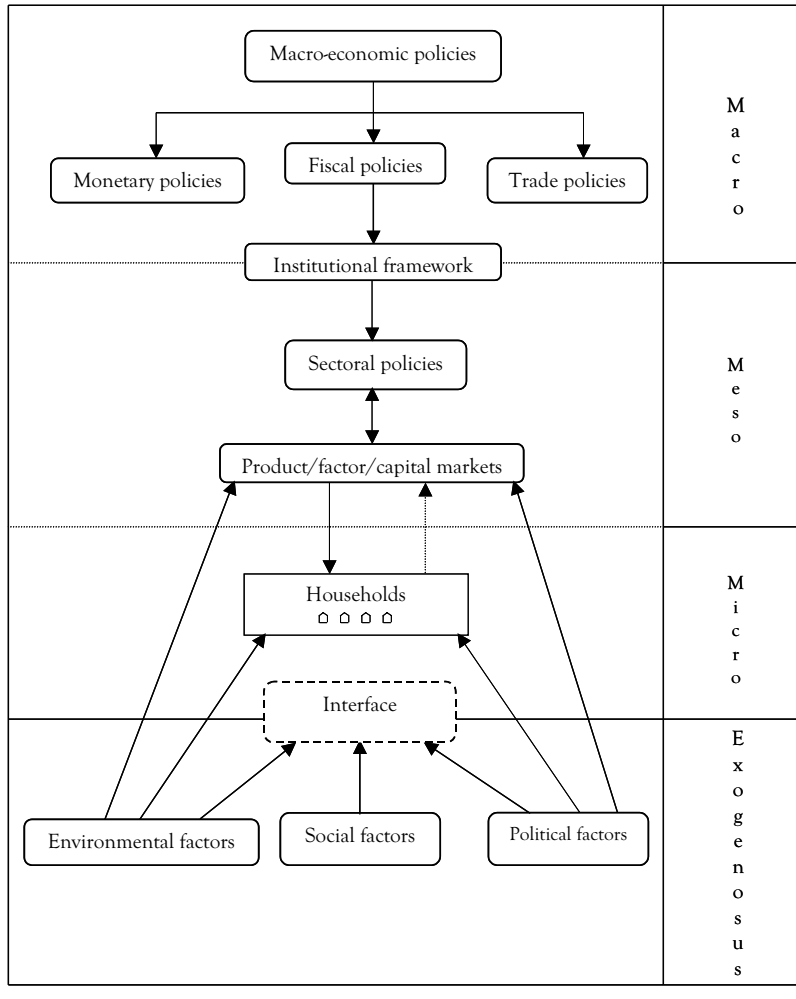

Figure 1. *Conceptual framework: macro, meso and micro linkages in land management and use decisions by households.*

the macro-economic and institutional arrangements with the central theme of correcting for policy distortions. In the process, they impact on the various sectors of the economy and the effects gradually trickle down to the micro level (households).

This framework, therefore, indicates that the overall impact of macro-economic and sectoral policies has a bearing on decision making of the people (farm households, traders, transporters, herders, forest product collectors etc.) who are embedded in the complex ecologies of the miombo woodlands. The outcome of their decisions, thus, affects the allocation and management of land, the state of the natural resource base and the environment, among others.

Project hypotheses

The project researchers tested several hypotheses in the 1996–2001 period. These hypotheses, which were tested across or within countries, were formulated with a view to

empirically test the strength and direction of the factors that affect the way land is used and, specifically, those that accelerate or decelerate forest cover. Some of the hypotheses were:

1. Reform policies under Structural Adjustment Programmes (SAPs) result in squeezed budgets for public services such as agriculture, forest extension and environmental protection.
2. Removal of subsidies on agricultural inputs, fertiliser in particular and floatation of currencies resulted in increased costs of farm inputs, making it difficult for farmers to increase or even maintain previous production levels on the same amount of land. This has resulted in agricultural extensification in an attempt to maintain previous food production levels. This extensification takes place in marginal lands or through clearing of forestland.
3. The tobacco industry (which contributes up to 80% of the foreign exchange earnings in some countries) has insufficiently been taxed to reflect the social cost it imposes on the environment with regard to use of fuelwood.
4. There is inadequate harmonisation and rationalisation of various sectoral policies with regard to their linkage to people, forests, natural resources and the environment.
5. Increase in human population is a key contributing factor to deforestation through expanded cultivation.
6. The current deforestation and environmental degradation is a result of 40 years of land policies that had no built-in incentives to safeguard the land by those who worked on it. These disincentives are related to land size, use and ownership.
7. Tight monetary polices under Economic Structural Adjustment Programme (ESAP) together with fiscal discipline has squeezed credit availability and raised interest rates, resulting in the shortage or even absence of credit for local communities and discouraged investments in sustainable agriculture. In turn, this discourages intensive methods of farming and prompts encroaching on forestland.

The message about these hypotheses is probably to ask ourselves whether some of them are testable in the circumstances of the countries covering the East African highlands that are the focus of this conference. More specifically, is testing some of these hypotheses likely to contribute to better understanding of the driving forces behind the use and management of land in the East African highlands?

Project outputs

The research team consists of 30 multi-disciplinary and inter-institutional pools of scientists from the five countries. So far outputs emanating from the project have been:

1. Case study reports from each country in the project
2. Technical papers and journal articles
3. Synthesis of policy effects on the woodlands based on the results from the five countries

4. Synthesis of institutional arrangements for managing forest resources
5. Occasional research briefs
6. Popular (less technical) writings for stakeholders—government, forestry departments, forest managers, non-governmental organisations and rural development planners
7. Improved research and training capacity through interaction of researchers, scientific writing workshops etc.

The future for similar projects

Based on the recent experience of policy research and analysis of the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA) it would appear that activities whose objective is to influence policy change (at whatever level) have to endeavour to go through the four-stage policy change cycle: policy data collection, policy data analysis, policy dialogue and policy action.

What recommendations can we draw from this paper? This is not a paper on the activities of the sustainable land policies in the East African highlands project. Therefore, recommendations will not be on policies, but rather on methods, processes and frameworks based on the experience of the miombo woodlands project and ECAPAPA.

1. To fully understand the forces that impinge on the farm households and their subsequent magnitude and direction, there is a need to have a holistic view of the macro, institutional, meso, micro and exogenous factors. All these factors need to be internalised in the planning and implementation of research projects and programmes.
2. Sharing results from testing hypotheses that seem to be relevant to similar agro-ecologies in other countries or regions will help in the sharing of best practices and informing on possible outcomes. Such information will reduce duplication of methods and processes and also help avoid false starts, hence leading to some efficiency gains.
3. The policy change cycle is a good guide to policy research work that is geared towards policy change.

Comments *by Simeon Ehui*

With on-going structural adjustment programmes and other reforms in the economy, crop prices are declining. It has been argued that this has led to the expansion of land under maize. However, if prices are falling, it follows that people move out of agriculture and not vice versa. The reason why land under maize increases may be because land is easily accessible.

There is a need to look into import and export sectors. With the current reforms like floating currencies, imported goods become more expensive and demand for local agricultural goods increases. Therefore, imported goods tend to be substituted by local goods.

Instead of relying on econometric regressions alone, it would be useful to try to look at a complete system of analysis to describe the economy right down to the land use systems. For example, policies affect land use through various mechanisms such as livelihood strategies.

There are some major issues: How does the smallholder farmer cope with liberalisation? What policy options are available to make smallholders more competitive?

Integrated resource management for improving land productivity in the Ethiopian highlands

J. Aune, Dereje Teklehaimanot and Balesh Tulema

NORAGRIC, Norway

Summary of findings

Numerous methods are available for increasing crop and livestock production in the Ethiopian highlands. Both national and international research institutes have developed technologies that are appropriate for the Ethiopian highlands. Examples of such technologies are the broad-bed maker for vertisols and cow traction. However, farmers' adoption of these technologies has been very limited and subsistence farming, characterised by low use of inputs and limited use of improved technologies, is still the dominant way of farming in Ethiopia. However, fertiliser use has increased in recent years because improved crop production packages have been introduced through the Ethiopian extension service. These packages have been accompanied by supply of credit. However, introducing these packages to farmers has not been without problems, particularly in dryland areas where crop failures are common. Farmers are often forced to sell animals to repay their debt. Despite these problems related to fertiliser use, it must be recognised that fertilisers do have an important role to play if farming in Ethiopia is to progress.

We believe that increased emphasis should be given to integrated approaches for agricultural development. There is a need to develop technologies and management schemes that can simultaneously enhance production, preserve the natural resource base and reduce poverty. Different technological options have different effects. A purely fertiliser based approach will not do much to conserve the natural resource base and address the problem of the poorer households, while a focus only on indigenous knowledge cannot generate sufficient growth. Carbon sequestration can become a new income-generating activity for rural communities.

One fundamental problem with Ethiopian agriculture is the low productivity of the livestock sector. This is to a large degree related to the composition of the livestock sector and limited fodder availability. We believe there exist options that can address both problems. Studies of the livestock composition in different parts of Ethiopia show that there are often more oxen than cows. This illustrates that a major reason for keeping animals in Ethiopia is draft power and cows are mainly used for reproduction and to get some milk. A comparison of the relationship between number of oxen and number of cows shows that the number of oxen is increasing. It is unlikely that it is possible to increase the economic output of this system, because use of inputs like urea

requires that there is an economic surplus from the system. A change in the livestock system will require a change in the tillage system. Such a change can only be realised if farmers change from oxen plowing to zero or reduced tillage.

Oxen plowing in Ethiopia dates back to 1000 years. The reasons for its widespread use in Ethiopia are cereal cultivation and particularly the cultivation of teff, which requires up to six passes with the *maresha* (the Ethiopian plow) and absence of tsetse fly in the highland areas. However, oxen plowing is currently under stress because land holdings are shrinking and fodder is becoming increasingly scarce due to rangeland degradation and costly rental mechanisms for oxen hire. In many areas of Ethiopia, farmers pay 50% of the harvest to get their land plowed. Particularly, female-headed households are in a weak position because plowing is culturally unacceptable for women farmers to plow with oxen. The zero-tillage system is for that reason particularly appealing for female-headed households.

Despite these constraints, oxen plowing is still the dominant tillage system in the country. However, alternatives to traditional tillage practices are under development. The Sasakawa Global 2000 programme and the Combating Nutrient Depletion project are working on developing zero tillage/reduced tillage. Promising results have so far been achieved both with maize and teff cultivation. Experiments with teff cultivation at Gare Arere area close to Ginchi showed that average yield on a vertisol was 1486 and 1424 kg/ha using zero and conventional tillage, respectively. Corresponding figures for a nitisol was 561 kg/ha for zero tillage and 470 kg/ha for conventional tillage. No herbicides were used in these experiments, as weeding was done manually. The weed situation did not differ significantly between tillage methods. Results from demonstration plots under maize also show that yields are equivalent or higher in reduced than conventional tillage. However, it must be expected that herbicides will be needed if farmers increasingly adopt zero tillage. Zero tillage is now rapidly expanding in Latin America and is used on more than 14 million hectares.

The advantages of zero tillage as compared to ox plowing include superiority in yield, soil erosion control, and the fact that farmers without oxen can keep all the harvest for themselves. A shift to zero tillage can also trigger a change in the livestock sector because oxen can be replaced by more productive animals such as milking cows. Oxen currently get the best quality fodder prior to and during the plowing season. There is therefore great scope for increasing livestock production if the scarce fodder resources are reserved for milking cows or for fattening sheep.

The soil resource is of central importance to the future of farming in Ethiopia. Currently, erosion levels are alarmingly high in many areas, and measures will need to be taken to halt the degradation of these resources. Agricultural practices that mimic 'mother nature' are also the best practices from an environmental point of view. This means that we are looking for production systems with a continuous soil cover and undisturbed surface layer, with a high degree of cycling of plant nutrients. The zero tillage system is an example of such a system because the soil surface remains undisturbed throughout the year. Zero tillage will also contribute to sequestering a large amount of carbon. Zero tillage will turn the soil from a source of carbon to a sink of carbon.

It is regrettable that sustainable agricultural practices are becoming difficult to practice because of low prices of grains. When maize price is down to Ethiopian Birr (ETB)[1] 40/quintal, any use of input will be extremely difficult.

Intensification will have to include a change in composition of livestock and increased access to fodder of good quality. One particularly promising technology is treatment of crop residues with urea. This is a well-documented quality enhancing technology, but it is used only to a limited degree in Ethiopia. Urea treatment of straw has an enormous potential in Ethiopia because more than 50% of fodder for livestock is from crop residues. Urea treatment of straw is widely used in China. An economic assessment of the urea treatment technology using a crop–livestock model showed that each Birr invested in urea treatment of straw gives a return of ETB 5, if the straw is fed to milking goats. It is likely that the limited use of urea treatment of straw in Ethiopia is related to composition of livestock, since feeding urea-treated straw to oxen will give only a very limited return.

Another very promising option for increasing fodder availability in Ethiopia is area enclosures. Area enclosures can be defined as areas that are protected from grazing and human activities for a given time period in order to regenerate the vegetation. Area enclosures are found in several parts of Ethiopia and promising results have been achieved. A study conducted in Tigray shows that considerable benefits can be obtained from area enclosures. Estimations based on counting bundles of grass from three different area enclosures showed that 3200 kgs of high quality grass could be harvested per hectare from an area enclosure. A cow weighing 250 kgs will need about 2200 kgs of dry matter per year. The bundles of grass can also be sold at the local market. The value of grass harvested from an area enclosure is about ETB 1850/ha, which is well above the economic benefit from cultivating teff, which is about ETB 600/ha, assuming a yield of 600 kg/ha. Area enclosures can alternately be used for tree plantations, but this will be at the expense of grass production. Counts in three different area enclosures showed that there will be about 992 more trees in an enclosed area compared to open land, eight years after the establishment of the enclosure. Wood production from an area enclosure is estimated to be about 248 m^3/ha of land. Given that a cubic meter of wood is sold for about ETB 50, this is equivalent to a value of about ETB 12,400/ha, 10 years after the establishment of the enclosure. Grass production will be reduced as the tree canopy develops. The value of grass production in an area dominated by trees was calculated to be about ETB 700/ha.

These results show that farmers can obtain great benefits from area enclosures. The costs of establishment and surveillance of area enclosures are also very moderate. Demarcation cost of the area enclosures will be about ETB 186/ha. Each household spends about ETB 5/year for the guarding of the land. The establishment of stone terraces within area enclosures is estimated at ETB 1018/ha, assuming a wage rate of ETB 7/day, 800 m of terraces per hectare, and that one man can build 5.5 m of terraces per day. Additional benefits of the area enclosures are increased biodiversity, less soil erosion, more continuous water discharge from the land and increased honey production

1. In 2002, US$ 1 = ETB 8.50.

due to more flowers. Area enclosures also improve the possibility for beekeeping since the vegetation cover will return. A survey study in three villages showed that 73% of the farmers in the area are in favour of establishing new area enclosures on their farms, whereas the remaining 27% are against it. Those who responded negatively particularly mentioned diminishing grazing land when new area enclosures are established.

Policy implications

Crop and livestock production are closely integrated in the Ethiopian highlands. It is not possible to change one component without affecting the other components of the system. There is, for example, not much point in upgrading the quality of fodder with the current composition of the livestock. Fertiliser has been easy to introduce because it does not require fundamental changes in the farming system. The most promising options for improving Ethiopian agriculture are increased emphasis on zero/reduced tillage, judicious use of inorganic fertiliser that will both increase grain and straw production, crop varieties and animal breeds that are responsive to inputs, urea treatment of straw or hay cutting, development of area enclosures and change in the composition of livestock from oxen to cows. However, such fundamental changes in the agricultural production system will not take place unless backed by favourable policies and an extension service focused on bringing about such changes. This implies a more market-oriented approach of the farming systems in the highlands.

The policies that can trigger a change in the agricultural system as described above are favourable price policies for outputs and inputs, development of local institutions with a responsibility for management of local resources, development of local credit institutions, and strengthening the research and extension programmes. It is particularly important that the government ensures a favourable relationship between grain prices and input prices. Strengthening of local institutions is a very important policy measure to improve management of communal resources such as area enclosures. The research and extension system should particularly focus on development of appropriate zero/reduced tillage systems and upgrading the quality of the straw. These can mutually complement each other and contribute to the development of more sustainable crop–livestock production systems in the highlands of Ethiopia. These suggestions for policy changes are very much in line with the five I's that the International Food Policy Research Institute (IFPRI) has identified as factors that promote agricultural growth. These five I's are innovations, infrastructure, inputs, institutions and incentives.

There is now a possibility through the Clean Development Mechanism under the Kyoto agreement for transfer of funds from Organisation for Economic Cooperation and Development (OECD) countries to developing countries as payment for carbon credits. Governments or community organisations are able to finance environmental rehabilitation activities and poverty reduction programmes through agreements with industries in the north that need to buy quotas for CO_2 emissions. Such arrangements

can in the future increase farmers' interests in the establishment of area enclosures, if some of the payment for the carbon credits is transferred to the rural communities. There is therefore a possibility that carbon sequestration projects may help finance land rehabilitation in Ethiopia. This is an option to explore in the future.

Comments *by Henry Ssali*

The paper points out that there are two main production systems in the Ethiopian highlands: crop and livestock and assert that the two are closely interrelated, hence any change in one affects the other. 'Technically appropriate' technologies have been developed to increase production. However, farmers' adoption has been limited due to a variety of reasons that are common to subsistence farmers. Low productivity of the livestock is a fundamental problem mainly due to: a) livestock composition (the sector focuses/concentrates more on draft animals), and b) fodder availability. The authors, therefore, argue for more integrated approaches to simultaneously enhance agricultural production and the natural resource base and reduce poverty. They find promising results in maize and teff based systems (grain yield on land cultivated using reduced tillage were greater or equivalent to those under conventional tillage). They also point out that as the livestock sector becomes more profitable, fodder quality can be improved through treating crop residues/grasses with urea. Approaches/options suggested include:

1. Change to reduced tillage that will:
   a. encourage shift from oxen to milking livestock leading to a more profitable livestock sector
   b. reduce land degradation (less erosion and soil organic matter destruction).
2. Develop enclosed areas to increase fodder availability and tree plantations
   a. examples with quantified monetary and environment benefits are given
   b. area enclosures can also take advantage of the Kyoto Clean Development Mechanisms Agreement that can finance environment rehabilitation activities.
3. Judicious use of fertilisers to increase grain production and crop residue (for fodder), and use of crop varieties and animal breeds that respond to inputs.

With respect to the policy implications, the authors recognise that for the above desirable changes to occur, favourable policies have to be in place, including:

- government has to ensure favourable relationship between produce and input prices
- local institutions for management of resources have to be strengthened
- there must be credit institutions
- research and extension programmes have to be strengthened.

Questions/comments

- What is the strategic importance of the highlands in Ethiopia?
- Seem to imply that adoption of technologies in the wetter areas is quite good and farmers in these areas have been able to satisfy credit conditions.

- What is the potential for the dairy industry?
- Are there current favourable and unfavourable policies?

Impacts of land management options in Western Kenya and Eastern Uganda

R.J. Delve[a] *and J.J. Ramisch*[b]

Tropical Soil Biology and Fertility Institute of the International Center for Tropical Agriculture (CIAT)
a. Uganda
b. Kenya

Introduction

Over the past 10 years, the image of agricultural and environmental crises in sub-Saharan Africa (SSA) has become increasingly common. Soil erosion and soil fertility loss are considered to be undermining the productive capacity of the agricultural systems. These problems have been ascribed to many different causes, including social, economic, biological and physical factors. Many authors have also highlighted concern over the increasing problem of land degradation in the highlands of East Africa, where increases in agricultural production in recent decades have been achieved through intensification of existing agricultural practices and through expanding the cultivated areas of land, especially in fragile environments. Soil degradation, soil erosion and loss of soil fertility have been widely quoted as resulting from these intensive and extensive agricultural production systems.

Blaming smallholder farmers for this degradation is over simplistic in the least. Furthermore, tropical agricultural production systems are characterised by dynamic features, with many examples of modified production practices that cope with and adjust to changes. Smallholder farmers use a wide range of resource management practices and production strategies specific to their agro-ecology to minimise risk, cope with change and shocks and manage the environment (ecological, social, economic etc.) they operate in. These can include, for example, agricultural intensification, expanded market-orientation, increased capital and labour investment. Alternatively, farmers have been found to exploit their resource base where constraints are too high, the returns to investment are too low (even negative, as when staple commodity prices plummet during bumper harvests), or environmental conditions are erratically variable for secure investment. Where purchased inputs or labour are scarce, mining the soil's nutrient capital resource can appear to smallholders as good economics and an acceptable cost of agricultural production.

This paper uses evidence from two sites in eastern Uganda and Western Kenya to investigate land management, land use changes and the policy environment within which smallholders have to operate and assess their impacts on the farmers' production strategies. Both sides of the border have similar agro-ecology and cropping systems, with eastern Uganda through to Western Kenya occupying a gradient with changing soil types, from the alfisols in Uganda to humic nitisols in Western Kenya, increasing

agricultural production and also increasing population densities from east to west. This has resulted in a range of land use systems to manage this gradient.

Land management technologies

Ugandan and Kenyan national research institutions (in collaboration with international agricultural research centres) have developed an array of technologies that can effectively address local production problems. For example, improved banana and maize varieties have been developed for various agro-ecological zones, as well as legumes and cover crops that improve soil fertility and provide fodder. Many of these technologies have, however, not been disseminated adequately to farmers and have, therefore, had little impact at the farm level. The need for improved dissemination of knowledge to farmers has been identified by many studies. To do this, it is increasingly being recognised that the best approach is one in which farmers, the local administration and the community participate actively. Examples of technologies developed in the region by collaborative research between farmers and scientists include:

Phosphorus replenishment. Phosphorus (P) is a major limiting nutrient to much of the region's crop production due to low soil P availability and the high P-fixing capacity of many soils, especially in Western Kenya. The socio-economics of smallholder production limit the feasibility of using fertilisers, but combining organic residues with locally available low-cost rock phosphate can improve P availability to crops. In addition, research on a P-fixing nitisol in Western Kenya has shown that soil P replenishment using seasonal additions of small rates of P fertilisers could be attractive to some small-scale farming systems. Seasonal additions of 25 kg P ha^{-1} increased maize yield with gradual replenishment of soil P. Smaller rates of 10 kg P ha^{-1} contributed to soil P depletion, while large seasonal applications of 150 kg P ha^{-1} resulted in low efficiency of applied fertilisers.

Legume cover crops. In regions where natural fallowing is still practised (as in eastern Uganda), green manure species like *Mucuna pruriens* and *Canavalia ensiformis* increases the following maize yields. In addition, the significant increases in associated maize stover production increased options available to farmers, such as using it for livestock feed or bedding, soil erosion control, compost making, or mulching the banana crop. In other research, incorporating 50 or 100% of the *in-situ* produced biomass did not result in significantly different increases in maize grain and stover yield. This would allow farmers to use 50% of the biomass produced for incorporation in the soil and the remaining 50% for livestock feed, sale to other farmers, or to produce hay for dry season feed. Increasing the resource management options and, therefore, the production options of the farming enterprise is critical where land sizes and the area available for non-food crop production are small, and where cash is not readily available to buy inputs for crop and livestock production.

Biomass transfer. In both Western Kenya and eastern Uganda application of high quality local materials, such as *Tithonia diversifolia*, has shown good potential to increase productivity. Work in Western Kenya, supplying a constant rate of 15 kg P ha^{-1} through combinations of Tithonia leaves, low-quality maize stover and triple super-phosphate (TSP), showed that maize yields increased between 18–24% as the share of P contributed by Tithonia in the residue–fertiliser mix was increased above 36%. The results indicate that a high quality organic input can be more profitable than using inorganic P, and comparable to or more effective than inorganic P in increasing P availability in the soil. Work in Uganda combining Tithonia with fertilisers also obtained the greatest benefits by maximising the proportion of Tithonia in the mixture.

Whilst technologies exist that increase soil productivity and are profitable for farmers, there are many factors limiting technology adoption. The fact that food production is the key priority of the farmer means that they are very risk averse and need to produce a food crop every season. Even where land is not apparently scarce, investing present resources based on the possibility of increased production in future, is not necessarily attractive to farmers. As a research farmer in Kenya commented, 'it is better to have even one gorogoro tin of maize (from a depleted field that was planted with maize) than to be guaranteed no maize at all this season by planting a cover crop we can't eat'. Issues of increased labour requirements for incorporation or collection of biomass are also commonly cited by farmers during evaluations of the organic technologies. In Western Kenya, there are even examples of teachers using 'free' labour of school children to harvest Tithonia for use on school plots.

The implicit assumption of most agricultural research is that farmers' current resource management decisions are not the optimal ones, and that providing them with better information would lead them make better choices. However, without understanding farmers' priorities and constraints the rationality of their current decisions will be misunderstood. Similarly, by ignoring farmers' existing knowledge (or not accurately locating the gaps in that knowledge), the impacts of improved land management technologies will be minimal. Agricultural knowledge, access to new sources of information and control of resources can vary considerably within a given community, especially across axes of difference such as gender or age. Technologies that are designed collaboratively by researchers, extensionists and farmers are more likely to correctly target the socio-economic and agro-ecological niches where they will be most relevant.

Adaptations by farmers

Innovations in using these soil fertility management technologies are very common. A recent survey identified many adaptations/innovations by farmers using cover crop and biomass transfer species not just for increasing crop production, but also for pest and weed control, consumption of the seeds and livestock feeding. Farmers assess the different management options available to them, and adapt them to fit their own circumstances and production objectives. Growing Tithonia on-farm in available niches (around the

field boundaries, for example) is one way of overcoming shortage of Tithonia and reducing the labour that would be needed if collecting the biomass from off-farm locations is to be undertaken. For other farmers, the rapid decomposition of Tithonia makes it 'more like a fertiliser' (i.e. immediate effect, with little residual benefit) and, therefore, less attractive than farmyard manure (compost of animal, household and crop wastes), which 'builds the soil' for the long term.

Recognition that innovation comes from multiple sources means that technology development must involve potential users from very early stages in the design process. To support this, extension must be more intimately linked with research to ensure that nascent technologies take fuller account of farmers' existing knowledge, practices and priorities. Dissemination would be of prototypes fully intended for modification or rejection by farmers and not of finished products. However, by treating technology itself as politically neutral, i.e. without knowing who benefits from existing practices or who will likely benefit from changes, policy recommendations relating to soil fertility management will remain too vague to truly assist policy makers, or be delivered through inappropriate channels to sectors unable to make use of them.

Implications of the policy environment on land management

While some of the constraints to crop production and examples of options available for alleviating soil productivity problems have been discussed at the farm level, many of the constraints facing farmers come from external forces, such as the malfunctioning of input and output markets, which can only be affected by modification of the policy environment. For example, the bumper harvest reported in Kenya and Uganda in the 2001 short-rain season led to sale maize at the prices that were often below production costs. In such situations, farmers face the prospective of losing money if they sell their maize to generate cash, but there is also no incentive for them to invest in their agricultural enterprises given the policy environment they operate within.

Clearly, innovations need to address food security and livelihood sustainability, not just increased production as a good in its own right. Policy interventions that would rationalise input and output markets, and buffer smallholders from their volatility, should have as their goals: a) increasing farmers' opportunities to innovate; and b) making investments back into agriculture attractive. One way in which such support could be given to smallholders would be by increasing investment in linking research, development and extension with farm communities.

In Kenya, the collapse of the formal extension network over the past five years has led to a shift towards farmer extension and farmer-to-farmer training through, for example, farmer field schools. This increased reliance on information diffusion through social networks requires a better understanding of the role of social capital in innovation. In contrast, in Uganda, a newly privatised extension service is being piloted in test districts across the country, where parish level farmer forums feed through sub-county and

counties to the district, which then contracts extension providers to provide the demanded services. This demand-led process has the potential to provide smallholder farmers with increased access to markets, agricultural inputs and extension services and improved access to information and technologies through the contracting of private sector service providers. This in turn will lead towards a more market-orientated smallholder production sector.

Comments *by Henry Ssali*

The paper focuses on a transect from eastern Uganda across the border to Kenya, with altitude ranging from 1000 to 1800 metres above sea level (masl), population density ranging from 200 persons/km^2 at the lower altitude range to over 1000 persons/km^2, and soils ranging from sandy, ferralsols where N is most limiting, to humic nitisols, where N and P are limiting. The farmers along this transect have small landholdings and market is not usually a problem, since the transect is along the Mombasa–Kampala highway, but with cases of glut in good seasons. Agricultural productivity is declining as the rapidly growing population over-exploits the land resources.

With respect to new technologies, there are improved crop varieties and soil fertility management technologies including fertilisers (organic and inorganic), legume cover crops, biomass transfer and agroforestry, and there are indications that some of the technologies are taking root since farmers are beginning to adapt them to fit into their circumstances. The authors, however, point out that although technologies are generally profitable, there are many factors preventing widespread adoption by farmers, including:

- availability of planting materials for soil management plant species
- availability of land for fallows (improved or not)
- labour requirements.

With respect to policy implications, the paper points out that with fluctuating produce prices, farmers face the prospect of losing money, hence there is little incentive for them to invest in sustainable land management. It is argued that demand-led extension has the potential to allow smallholder farmers to gain from increased access to markets, agricultural inputs and extension services and improved access to information and new technologies. However, for this to succeed there must be investments in proper research–development–extension–farmer linkages.

Soil organic matter and its relationship to soil fertility changes in Uganda

H. Ssali

National Agricultural Research Organisation (NARO), Uganda

Background

Soil resources studies in Uganda have indicated that most of the soils are old and highly weathered with little mineral reserves, hence soil organic matter (SOM) is very important as a source of nutrients and to maintain good soil physical properties. As a result, SOM is used as the best indicator of soil productivity.

Field trials (1700 experiments at 62 centres covering the entire country) in the 1960s indicated that the SOM level was more related to texture, particularly the clay and silt content, than other parameters like rainfall or farming systems. It was found that where silt and clay content was greater than 26%, the SOM range was 3 to 7%, while where silt and clay content was less than 26%, the SOM range was 1 to 3%. It was also found that SOM was closely related to major parameters of soil fertility (indices of crop nutrient reserves, soil pH, and cation exchange capacity (CEC)), and there was little response to fertiliser application if SOM was greater than 3.5%. Subsequent studies indicated that SOM decreases during the cropping phase and that SOM was higher following a good fallow period. In addition, inputs (organic and inorganic) applied during the cropping phase help maintain SOM at higher levels, compared to cases where no inputs are applied, and green manures had little effect on SOM levels.

Current soil organic matter and soil fertility status

A number of recent studies based on point/plot sampling surveys around the country have indicated that soil fertility is declining. However, there has not been a systematic survey to indicate what has happened over time. As part of the 'Sustainable land management policies project in Uganda', it was decided to revisit sites that were surveyed in the 1960s to evaluate what has happened over time. Although sites were not geo-referenced in the 1960s, it was possible to identify most of them based on field records found at Kawanda Agricultural Research Institute (KARI). Seven centres (139 fields) representing light soils (where clay and silt content was less than 26%) and heavier soils (where clay and silt content was greater than 26%) were selected.

Fields were located by interviewing extension officers, chiefs and farmers. Identified sites were geo-referenced and soil samples taken and analysed. Analysis was carried out at KARI, where the 1960s analyses were done and the same analytical methods are still being used. According to the farmers interviewed, most of the fields have not been

rested since the 1960s and it was observed that fields found under fallow were in a poor state and appeared to be abandoned rather than a deliberate fallow.

Laboratory analysis indicated that SOM distribution still depended on texture and that the magnitude of SOM had not significantly changed. However, in many cases, soil pH, extractable phosphorus (P), calcium (Ca) and potassium (K) were below critical levels despite the little change in SOM. In some cases P, Ca and K levels in the topsoil were 20 to 70% of the levels found in the 1960s.

Policy challenges and implications

Under continuous cultivation, nutrients in the topsoil are decreasing and soils are becoming more acidic. Under prolonged continuous cultivation conditions, total SOM level may not be enough to indicate soil fertility status, hence there is a need to identify a better indicator. To arrest the land degradation process, appropriate soil and water conservation methods to reduce nutrient losses and acidification through reduced erosion and increased use of inputs will be required. Where nutrients are leached, rotating shallow-rooted crops and deep-rooted crops/grasses or agroforestry species should be encouraged to increase recycling of leached nutrients and reverse acidification trends. For continuously cultivated soils, inputs are necessary to reduce degradation and nutrient imbalances due to losses through erosion and nutrient exports. Although the fertiliser market in Uganda is liberalised and there is no tax on fertilisers, the fertiliser market is not developed and there is a need for financing, training and information provided to dealers, stockists, farmers, extension agents and policy makers.

There should be efforts to find markets and to stabilise farm-gate produce prices. Where produce prices are low or fluctuate greatly, farming may not be profitable enough or too risky to encourage farmers to invest in proper land management (soil and water conservation, use of inputs to replace nutrient losses or improve soil conditions (e.g. increasing soil pH through liming, long term strategies to increase SOM)).

Comments *by Jens Aune*

This paper gives a good insight into the trend of soil fertility in selected sites in Uganda. An important finding is that soil organic carbon alone is not any more a good indicator for soil fertility and that investments are needed in order to restore the fertility of the soils. This result will have consequences for fertiliser recommendations in Uganda.

The method used in this study was to identify previous sites where soil samples were taken in the 1960s and then take new soil samples from the same sites in order to determine if there are any clear trends in the soil fertility. This is an innovative and appropriate method for establishing trends in soil fertility that is rarely undertaken. However, despite its merits it has some shortcomings.

There are problems comparing soil analyses results that were taken 40 years ago as compared to soil analysis now. There could be differences in how the sampling was done in the fields (depth and site identification) and in the type of equipment and methodology used in the soil laboratory. This makes it difficult to give a precise estimate for how much the different parameters of soil fertility have changed. In order to avoid this problem, it would have been better to store the soil samples from the 1960s and re-analysed them. For the future, it is therefore important to store the soil samples. However, despite this shortcoming, the results are still valid.

The results showed that there is not so much change in soil organic carbon. The reason is probably that the most easily decomposable soil organic matter was gone when the samples were taken in the 1960s and that the soil organic carbon that remained after that time had a very stable pool of soil organic carbon. This pool cannot provide much plant nutrients.

The potential benefit of velvet bean (*Mucuna pruriens*) and N-fertilisers in maize production on contrasting soils in Uganda

C.K. Kaizzi,[a,b] *H. Ssali,*[a] *A. Nansamba*[a] *and L.G. Vlek Paul*[b]

a. National Agricultural Research Organisation (NARO), Uganda
b. University of Bonn, Germany

Per capita agricultural production and crop yields in Uganda, as in other sub-Saharan African (SSA) countries, is declining. The main contributing biophysical factors are nutrient/soil fertility depletion, low soil fertility, particularly N and P deficiencies, cultivation of marginal land and continuous cropping. In addition, loss of nutrients as components of crop harvests, through runoff and soil erosion, is on the increase for most of the farming systems. All of these have contributed to the negative nutrient balances reported for SSA countries and for the farming systems of eastern and central Uganda. One of the limiting factors that lead farmers to use low or no external inputs is lack of financial capital. Smallholder farmers use low-input production technologies, without appropriate soil and water management practices. Equally, there are constraints limiting the use of on-farm inputs such as organic materials. In the case of green manure or *in situ* biomass production, farmers have to sacrifice land and invest labour, both of which lead to competition with other farm activities that require the same inputs.

Little is known about the economics of green manure when used in combination with other sources of nutrients. The objective of the study is to assess the most suitable strategy for soil fertility maintenance for resource poor farmers cultivating soils of different fertility status in eastern Uganda. The N-replenishment strategies investigated in this study include: 1) the exploitation of biological nitrogen fixation (BNF) through the use of velvet bean (*Mucuna pruriens*) in relay rotation; 2) use of *mucuna* as an improved fallow; and 3) inorganic fertilisers.

On-farm research was conducted with 58 randomly selected farmers at four sites in eastern Uganda, namely, Nemba/Kasheshe, Agonyo II, Odwarat and Kongta in Sironko, Soroti, Kumi and Kapchorwa districts, respectively. The sites are located along a transect that captures variability in soil productivity, land use intensity and agricultural potential. The farmers' fields were characterised through analysis of a composite soil sample collected from the 0–20 cm depth for pH, organic matter, extractable P, exchangeable K and Ca plus texture. The four sites were divided into two groups using soil productivity and rainfall reliability. Kongta and Nemba/Kasheshe represent the more productive areas while Odwarat and Agonyo II represent the less productive areas.

Mucuna biomass production was not significantly different at Odwarat, Agonyo II, and Nemba/Kasheshe sites, but was significantly less at the higher altitude of Kongta.

Mucuna accumulated 192, 169, 204 and 77 kg N/ha at Agonyo II, Odwarat, Nemba/Kasheshe and Kongta, respectively. It is estimated that 42% of the N was derived from the atmosphere. Farmers' fields at each site were grouped into low or high productivity using the maize grain yield from the farmer practice (control plot). Significant difference in maize yield between the two farmer groups was attributed to differences in soil properties at Kongta and Nemba/Kasheshe. At Odwarat, the difference was attributed to the number of seasons the field has been under cultivation. There was a significant response by maize to the application of inorganic fertilisers following a *mucuna* fallow or relay. However, increasing the inorganic N level from 40 to 80 kg N/ha did not significantly increase maize yield further. A 'partial budget' analysis indicated that higher economic benefits were obtained from the alternative organic N-replenishment strategies on highly productive soils.

Conclusions and policy recommendations

Mucuna has a potential to accumulate a large amount of biomass and N from the atmosphere, which is of great importance in agriculture of the smallholder farmers in Uganda. *Mucuna* and inorganic N fertilisers have the potential of increasing maize yield in soils of contrasting productivity. The magnitude of yield response and the economic benefits depend on the level of soil fertility. Economic returns are higher with low levels of inorganic N fertilisers and *mucuna* relay. Higher economic benefits are obtained with the different strategies on the more productive soils. However, on less productive soils, economic benefits are lower when the fertility levels have gone down. In such areas, farmers derive more benefit by not investing in any N replenishment strategy. Though this may be a rational strategy, the sustainability of the system is compromised, threatening long-term survival.

The results of this study have shown that in the current situation of limited resources, it is better to invest the resources for soil fertility replenishment in areas with more productive soils because of higher economic benefits. However, soil fertility replenishment in less productive areas is still needed to ensure food security.

Comments *by Jens Aune*

This paper examines the potential of using the velvet bean (*Mucuna pruriens*) to enhance soil fertility in Uganda. This approach for soil fertility restoration is very interesting because inorganic fertilisers are costly and not available everywhere.

The results showed that *mucuca* can fix large amounts of nitrogen and contribute to increase the productivity of the soil. The best economic return is found on the most productive soils.

The paper does not present any information on how this technology has been evaluated by the farmers. Such information is normally provided in this type of on-farm

research. Farmers are always the best placed to rate new technologies. It would also be helpful to know about the labour demand of this technology, because if this is not known, it is difficult to assess this technology. The plot size used in this experiment was only 28 m^2. Such a small plot size makes it difficult for the farmers to assess the technology and assessing labour use will also not be very accurate when plot size is so small. Plot size should at least be 200–300 m^2 in on-farm experiments. The study has only addressed the soil nitrogen problem, because phosphorous was applied to the plots. Legumes cannot solve the phosphorous problem, and it may therefore be beneficial for the farmers to combine the use of organic and inorganic fertilisers.

Policy analysis for sustainable land management and food security in the Ethiopian highlands: A bio-economic model with market imperfections

S. Holden,[a] *Bekele Shiferaw*[a] *and J. Pender*[b]

a. Agricultural University of Norway, Norway
b. International Food Policy Research Institute (IFPRI), USA

Introduction

Ethiopia is one of the poorest countries in the world and its population of more than 60 million people lives mostly in the highlands. The food security of these people is threatened by land degradation and droughts that cause declining and highly variable land productivity. The policy to use credit to stimulate adoption of high yielding varieties and fertiliser use has not been very successful in the most fragile and drought prone Ethiopian highlands. There is an urgent need for alternative development strategies that address land degradation and food insecurity in less-favoured areas where drought risk is higher and/or market access is poorer.

The material conditions and low investment levels cause severe market imperfections due to high transaction costs and imperfect information, and these imperfections contribute to the problems. Improving markets may therefore be one important element in a new policy for sustainable development. Still, there is no guarantee that piecemeal improvements of some markets will lead to economic growth and more sustainable land use. It is even possible that improved access to some markets can lead to more land degradation.

We have in this paper developed a bio-economic model for a less favoured, severely degraded, densely populated area with fairly good market access in the Ethiopian highlands. The recent droughts have made the area dependent on food aid. Even though the area is favourably located near the main road between Tigray and Addis Ababa, there are significant market imperfections that affect land productivity in the area. There are very good biophysical as well as socio-economic data from this area and we can therefore rely less on theoretical assumptions and more on empirical reality when constructing the model.

In this paper we assess the impact of alternative policies to reduce poverty, increase food security and promote more sustainable land use in the study area. Specifically, we assess the impact of a) improved access to off-farm employment, b) access to food-for-work (FFW), and c) promotion of planting of eucalyptus on land unsuitable for crop

production on household welfare, agricultural production, conservation investments and soil erosion.

Model description

The novelty of the model presented here is that it is a dynamic non-separable household model that simultaneously integrates economic optimisation in production and consumption with inter-temporal environmental feedbacks, allowing for non-linearities in the constraints as well as the objective function. The models are calibrated and aggregated to resemble the actual pattern of household interactions through their participation in imperfect factor and output markets. These market imperfections include limited access to off-farm employment, price bands for outputs and labour, a constrained rental market for land through share tenancy, an oxen rental market through exchange with labour only, constrained access to formal credit in kind (for fertiliser) or to informal credit at a high interest rate.

The models also incorporate risk averse behaviour through a constant partial relative risk aversion utility function, production risk due to drought, and downside risk aversion to taking credit for fertiliser. Drought also affects prices for crops and livestock and price expectations and these have additional effects on household production and welfare. The models endogenise the effects of land degradation in the form of soil erosion and nutrient depletion. The availability of biophysical data from conservation experiments in the study area allows us to estimate erosion rates as well as crop productivity responses on different soils in the study area. The model furthermore integrates crop and livestock interactions. Crop choice, building or removal of conservation structures on different types of land, fertiliser use and manure use are endogenous decisions that affect the rate of land degradation. These decisions affect erosion and nutrient depletion rates that again determine crop productivity in later years.

Results of model simulations

The model simulations indicate that improved access to markets for credit and off-farm employment do not necessarily lead to more sustainable land use. We find that better access to off-farm employment reduces farm households' incentives to invest in conservation and that this leads to more overall soil erosion and more rapid land degradation. This is the case even though total agricultural production (crop and livestock) and farm input use are reduced when access to off-farm employment is improved. This is because conservation investments only require labour (not cash) and the opportunity cost of labour is increased with better access to the labour market. The private return to labour in conservation is not so high that it pays to hire labour for this purpose.

The simulations also indicate that there are entry barriers in wage-employment. Better (unlimited) access to off-farm employment at the low seasonal wage rates, typical in the study area, had a considerable positive impact on household welfare, but increased the need to import basic food grains to the area. There is, therefore, a need to complement a policy focusing on the development of the non-farm sector with a policy that ensures conservation of the natural resource base.

We find that FFW programmes may be used to improve household food security and to promote more sustainable land management. However, there is a danger that such programmes may undermine private incentives for food production and land conservation. By linking FFW to conservation investments and timing them outside the production season, negative side effects may be minimised. Local participation in project identification, design and implementation is also important for increased commitment and to ensure lasting effects of the investments.

Stimulation of planting of eucalyptus is a promising policy alternative. If land unsuitable for crop production is planted with eucalyptus and market outlets for the trees can be assured, this can provide substantial increases in household incomes. This may not have large effects on incentives to conserve cropland or on own food production. The demand for food may increase, however, as a result of higher incomes from sale of trees and this may increase food deficits and the need to import food to the area.

FFW may be used to stimulate tree planting as well as cropland conservation. Policies combining promotion of tree planting and conservation through FFW may have the potential to achieve win-win benefits in terms of poverty reduction and more sustainable land use. Careful design and implementation is required to maximise such benefits.

Credit policy and intensification in mixed crop–livestock systems: A modelling perspective

M.M. Ahmed,[a] *P.V. Preckel*[b] *and S.K. Ehui*[a]

a. International Livestock Research Institute (ILRI), Ethiopia
b. Purdue University, USA

Introduction

Interactions between crop and livestock production can have a significant impact on productivity of both activities. Evidence from many sub-Saharan Africa (SSA) countries indicates that substantial potential exists for improvement of livestock productivity as long as crop intensification is possible. In southern Mali, for example, farmers are using high levels of inputs on many crops (e.g. cotton, maize and sorghum) and improved leguminous feed crops (e.g. *Dolichos lablab* and *Stylosanthes* spp.) are being introduced along with improvements in the management and storage of crop residues and cowpea hay.

In the mixed crop–livestock system of the Ethiopian highlands, the potential for crop intensification also exists and strategies to promote such intensification are becoming an important policy issue due to high population pressure and land scarcity. Under these conditions, crop intensification is likely to lead to opportunities for improvements in livestock productivity through increasing feed availability. Agricultural intensification entails a multi-dimensional process of responses to increasing population density, technological change and commercialisation or any combinations of these. It is characterised by substitution of labour for land in the initial stages followed by more continuous cropping, systems of crop rotation and soil improvement and modern yield-enhancing inputs such as inorganic fertiliser and improved seed.

One useful policy question is how can intensification of crop and livestock activities be promoted? Access to credit is one strategy for promoting the adoption of yield-enhancing technologies. Governments have often used credit programmes to promote more agricultural output, and credit policy could play a more efficient and equitable role in development if appropriate policies were adopted. However, advancing credit to smallholder farmers for encouraging technology adoption is a complex policy issue. Some of the major issues are the amount and form of credit, interest rate and repayment schemes to be provided for farm households. The objective of this on-going research is to identify the appropriate mechanisms to advance credit to smallholder farmers for encouraging intensification. In this paper, we analyse the impact of advancing credit in the form of fertiliser and seed to smallholder farmers with different levels of wealth using a household bio-economic modelling approach.

Modelling impact of credit

A household model of the mixed crop–livestock farming system of the highlands of Ethiopia for analysis of the impact of a wide range of technologies and policies affecting smallholder farmers is under development. The model is based on a bio-economic framework where the productivity of both enterprises is determined by the biophysical environment including soil productivity and weather, and the available technology including traditional and improved seeds, inorganic fertiliser, soil fertility management and erosion control. The household supplies feed and labour to the livestock herd and labour and crop inputs to the farm. In return, the household receives livestock services and livestock and crop products for own consumption and sale as well as manure for fuel, improving soil fertility and sale. Through the market, the farm surplus is exchanged for food, feed, fuel and cash (or other consumption goods). The policy environment affects the outcome of the marketing activities. The model consists of activities broadly relevant to crop production, livestock production, resource management and consumption.

Data

The model is applied to data collected from the Holetta area located 40 to 70 kms west of Addis Ababa, in the vicinity of two small towns: Holetta and Addis Alem. The altitude of the area is around 2600 metres above sea level (masl) and receives an average annual rainfall of 1100 mm. Average minimum and maximum temperature are 11.6 and 15.3°C, respectively. Farmers in this area depend exclusively on rain-fed agriculture and most crops are grown in the main rainy season. The average household owns about 0.35 ha of vertisol land and 1.42 ha of the light and mixed upland soil land. Most of the land (1.26 ha) is allocated to the three major crops: wheat, teff and barley. About 0.2 ha is allocated to pulses, mainly horse beans and field peas and about 0.17 ha to gardening and other crops. The production is geared towards satisfying the household food requirements as well as provision of feed in the form of straw and hay for livestock.

Besides crops, the typical household keeps a herd of animals, mainly consisting of dairy cows, at least two oxen for plowing, heifers, bulls, goats, sheep and chicken. Because of the dependency on animal traction for crop production and lack of market for animal draft services, keeping at least a pair of oxen and a follower herd (heifers and bulls) for replacement is necessary despite the feed shortage. To ease the feed shortage, dairy–draft crossbred cows are encouraged. This technology can allow the farmer to reduce the herd size while maintaining the capacity for both animal traction and milk production. However, farmers are reluctant to use crossbred cows.

Results

For model validation, we compared, observed and predicted average cropland allocation and annual consumption patterns of sample farmers from Holetta. Predicted land allocation appears to be very close to the reality in the area. However, the model overestimated land allocated to wheat (0.73 ha) and teff (0.65 ha) compared to the observed area of 0.55 ha each. The model also overestimated the area allocated to the two pulse crops. However, the model successfully predicted the diversification behaviour of the household. On the consumption side, the model predictions of calorie and protein intake are very similar to observed behaviour. However, it underestimated consumption of milk and other food and non-food items substantially, while it predicted barley, wheat, teff, horse beans, eggs and field beans within a margin of less than 10%. Taking cereals together (barley, wheat, teff and sorghum), the model predicted household intake of 1289 kg/year compared to the observed average consumption of 1229 kg. Similarly, the model predicted total household consumption of pulses (field peas and horse beans) of 107 kg compared to the average observed consumption of 105 kg. Given the complexity of the farming system, the large number of crop and consumption choices and the possibility of substitution between them, we conclude that the model approximates observed behaviour satisfactorily and, hence, can be used with confidence to measure response to alternative scenarios.

Several alternative credit options were simulated. Model results show that the value of crops produced is the lowest in the absence of credit and input markets. In contrast, households will apply substantial quantity of fertiliser to their crops even in the absence of a credit market, given that the input market is functioning. As a result, the value of crops produced increases by 35%. With access to in-kind credit, fertiliser use increases by 51% compared to the case of no credit. This allows the household to increase the value of crops produced by 50%. This increase in gross returns is the impact of both fertiliser and credit. With access to cash credit, the average household applies less fertiliser compared to those receiving in-kind credit. This is because the interest rate for cash credit is assumed to be higher and because some of the credit is diverted to current consumption.

Despite the capital constraint facing households, they may still purchase fertiliser in absence of credit. How they can afford to do that? The model results show that the household substitutes less preferred food for more preferred food, consumes fewer calories and, thus, spends less on current consumption. This reflects the high profitability of fertiliser application in the study area.

Policy implications

Households appear to adjust cropping plans according to availability of credit and expected production. Without purchased inputs, the household allocates almost all land (97%) to cereals and pulses to satisfy food subsistence requirements of the households

compared to an allocation of 85% for households with access to cash credit. However, with increased productivity and lower per unit cost of production, some food crops may become cash crops. As expected, use of high-yielding inputs (seed and inorganic fertiliser) allows the household to shift some land to cash crops such as linseed and rape seed as well as to forage to feed livestock.

When cash credit is available, the household apparently diverts its available resources for current consumption. With access to cash credit, the household may use some of the credit for current consumption substituting current consumption for future consumption. This reflects the degree of capital constraint of households. The results support the hypothesis that credit encourages intensification of the smallholder farming system of the Ethiopian highlands. This is expected to indirectly respond to the prevailing animal feed constraint. Since in-kind credit through government agencies is not a perfect substitute to a well-functioning credit market, development strategies should emphasise creation of credit market and smallholder access to credit through creation of micro-credit institutions. At the same time, effective functioning of the input market is required to facilitate access of smallholder households to inputs. Some issues still remain to be evaluated, including the repayment schedule and optimum interest rate.

Land improvement and technology diffusion in Uganda: A bio-economic multi-agent approach

J. Woelcke, T. Berger and S. Park

Center for Development Research (ZEF), University of Bonn, Germany

Introduction

Under the regimes of Idi Amin (1971–79) and Milton Obote (1980–85), Uganda's economy plunged into a prolonged crisis with negative real growth rates of gross domestic product (GDP). In 1987, President Museveni's government introduced an economic recovery programme in co-operation with the International Monetary Fund (IMF) and the World Bank, aiming at market liberalisation, privatisation and decentralisation. Although these reforms had positive impacts on the Ugandan economy (real growth rate of GDP has averaged 6% per annum), the productivity in the agricultural sector has either stagnated or declined.

Land degradation is generally assumed to be a major factor contributing to declining agricultural productivity, poverty and food insecurity. Recent studies in eastern and central Uganda have revealed high negative nutrient balances for most of the cropping systems. Addressing the issue of sustainable intensification of agriculture, the Ugandan Government published a 'Plan for modernisation of agriculture (PMA)' in 2000 as part of the 'Poverty eradication action plan' with the vision of eradicating poverty through a profitable, competitive, sustainable and dynamic agricultural and agro-industrial sector. The priority areas for action are: improving access to rural finance and markets, research and technology development; sustainable natural resource utilisation; and improving management and education for agriculture.

Research objectives

The proximate causes of land degradation (e.g. very low use of inorganic and organic fertilisers, declining fallow periods, deforestation, crop production on steep slopes with limited investments in terraces or other conservation measures) are relatively well known, but the core of the problem is of economic nature. Poor rural households in Uganda have to cope with a situation where land productivity and, therefore, farm incomes are stagnant or declining. The majority of rural households depend on agricultural production as the main source of income, though the importance of off-farm incomes tends to increase as the average farm size declines. Financial constraints and imperfect market conditions induce many farm households to adopt livelihood strategies

that contribute to nutrient depletion. Additional labour and land constraints are limiting the households' ability to invest in land improvements. It is therefore an important but difficult task to design public policies that make these technologies affordable and adoptable, especially for the poor farmers.

The literature shows that factors that influence the adoption of technologies in general include farm size, tenure, age, education and risk. It is less clear, though, which specific constraints farm households face in the adoption of ecologically sustainable farming practices, what the optimal levels of adoption of these practices are, and what their impacts on household income and natural resource conditions are. Against this background, this study has been carried out at the farm household level in Uganda to improve the understanding of key economic factors affecting land management decisions in the context of nutrient leaching, resource constraints and fertiliser application.

Consideration of the problems presented above led to the following empirical research objectives:

1. Identify the most binding factors affecting land use practices and adoption of new technologies (e.g. labour shortages, capital constraints, imperfect capital markets, distorted input and output prices and transaction and information costs).
2. Explore the feasibility of land management practices leading to non-negative nutrient balances from the farm households' point of view.
3. Explore the incentives of policy and institutional interventions mentioned as priority areas in the PMA (e.g. development of local credit markets, promotion of improved technologies, labour exchange institutions) on the decision making of farm households.

Multi-agent approach to bio-economic modelling

Sampling procedure

The International Food Policy Research Institute (IFPRI) and the Centre for Development Research (ZEF) have identified the predominant development domains in Uganda based on a stratified random sampling. Three factors were used for the stratification: agricultural potential, market access and population density. Two villages in Iganga District, which represent a programme-induced development pathway with high market access, high agricultural potential and high population density were selected for this study. A listing of households in both villages indicated that approximately 7% of the households were conducting agricultural technology trials in co-operation with the International Centre for Tropical Agriculture (CIAT) and Africa 2000 Network (A2N).

For the first round of the household survey, stratified random sampling was performed in order to capture the correct proportion of trial farm households in the sample. A principal component analysis and a subsequent cluster analysis helped to identify the following four representative household types: subsistence farm households

(30%), semi-subsistence farm households (52%), commercial farm households (10%) and trial farm households (7%). Out of each group, households closest to the cluster centroid were selected for the second round of the household survey. The main objective of the second round of the household survey was to collect biophysical data at plot level, detailed input–output coefficients and estimates for farm income analysis. Additionally, CIAT provided farm trial data of 4 seasons in 2000 and 2001 together with soil data for the estimation of yield responses to fertiliser application.[1]

Modelling approach

Bio-economic models combine socio-economic factors influencing farmers' objectives and constraints with biophysical factors affecting production possibilities and the impacts of land management practices. Implemented as multi-agent systems, these models may identify the optimal level of technology adoption and the impact on incomes and natural resource conditions for heterogeneous household agents (normative analysis), as well as elucidate the likely policy responses and outcomes from agent–agent and agent–environment interactions (positive analysis).

The bio-economic multi-agent approach chosen for this study consists of three major components: mathematical programming models at farm household level to reflect the decision-making processes under different constraints, artificial neural networks (ANN) as a yield estimator and nutrient balances as a sustainability indicator. The agent's decision-making problem is captured through mixed-integer linear programming consisting of 507 variables and 201 constraints. The results of the yield estimator and computations of nutrient balances are incorporated into the programming model. Two model versions have been developed: a comparative-static version, implemented as a discrete multi-agent system (i.e. without inter-household linkages), to identify current constraints and optimal adoption levels at farm household level (normative analysis); and a dynamic version, implemented as a connected multi-agent system, to forecast the diffusion of innovations together with the evolution of farm incomes and natural resource conditions over time (positive analysis). The research has not been completed and so this paper presents results from the normative model.

First simulation results

In the normative analysis undertaken so far, the objective function at the farm household level maximises the household income subject to financial, technical and sustainability constraints. We include here also the nutrient requirements and consumption preferences that the households articulated during the in-depth interviews. The programming model computes the optimal production and consumption plans based on a lexicographic utility concept: the households first satisfy their nutrition goals

1. The provision of trial data from Anthony Esilaba, CIAT, is gratefully acknowledged.

before maximising the household income subject to numerous resource constraints. Model validation was conducted by measuring the association of model solutions with observed values.[2]

Result #1: Binding constraints and feasibility of non-negative nutrient balances: In the first simulations, we tested whether under current constraints the adoption of ecologically sustainable farming practices is financially and technically feasible. For each representative household, we investigated several scenarios taking into account the given resource endowments, financial and technical coefficients and searched for land management practices leading to non-negative nutrient balances.[3] The scenarios revealed that only the commercial farm household could realise non-negative nutrient balances when the binding capital constraint was relaxed through provision of credit. For the other farm household types, the priority of satisfying the food requirements of its members prevents achieving non-negative nutrient balances.

Result #2: Introduction of credit, improvement of price relations and promotion of labour exchange: We tested then from a normative point of view whether certain technological innovations in combination with changing conditions of the socio-economic environment would have the potential to improve the negative nutrient balances substantially. In these simulations, we incorporated several policy variables based on the 'Priority areas for action' defined and published in the PMA by the Ugandan Government in 2000.

Under current market conditions, none of the household types could profitably apply any of the promoted fertilisers besides rock phosphate. Input prices would have to decrease or output prices increase substantially and credit would have to be provided to the farm households in order to adopt these innovations profitably. An exception is the trial farm household who could profitably adopt NP-fertiliser without the provision of credit, but only on a very small piece of land (0.02 ha). In general, output prices would have to increase by 50% and costs of fertilisers to decrease by 70–80% to induce a profitable adoption of NP and NPK.

Relaxing the seasonal labour shortages in addition could in some cases lead to a significant increase of NPK adoption. Labour exchange within the village, as a form of labour acquisition, would allow the semi-subsistence farm household, for example, to profitably expand land under NPK-fertiliser from 0.3 ha to 1.3 ha. The total gross margin per year could then be increased from Uganda Shilling (UGX)[4] 1.49 million in the baseline scenario to UGX 1.94 million. The application of NPK-fertiliser would also lead to a substantial improvement of nutrient balances. In the baseline scenario, the

2. The model results were regressed on observed values, whereby an intercept of 0 and a slope of 1would indicate a perfect association. The R^2 values obtained are 0.95. 0.99, 0.89, 0.94; the values obtained for the intercepts are 0.04, –0.01, –0.03 and 0.06; and the values obtained for the slopes are 0.96, 1.01, 1.02 and 0.83.
3. For these scenarios constraints were added, which force the model into non-negative balances for N, P and K.

semi-subsistence household, for example, has a balance of –52, –12 and –62 kg/ha of N, P and K, respectively; in the scenario with improved price relations, credit and labour exchange it has a balance of 16, 76 and –1 kg/ha of N, P and K, respectively.

Market incentives

The simulation experiments undertaken so far reveal that substantial improvements of the market environment in eastern Uganda are needed to give farmers sufficient incentives to adopt more sustainable land management practices. What are the potential improvements in the output and input markets that could change relative prices in agriculture and, thus, help provide these incentives? The market environment in Iganga, as in many parts of Uganda, is characterised by high transaction and transportation costs. Imperfect competition is leading to a low level of output prices. A mark-up of 60% between the price farmers receive and the price retailers were offering has been estimated. One essential step to reduce such a high mark-up would be to improve the market transparency by implementing a market information system. Inefficiency in procurement, high transportation costs and absence of competition are, on the other hand, leading to unreasonably high input prices, especially for fertiliser. It has been estimated that c.i.f. price in Kampala of fertiliser could fall by a quarter only by increasing the volumes shipped to levels that would justify shiploads and trainloads. Most of the fertiliser is delivered to stockists in 50 kg bags. The fertilisers are repacked into smaller units of 5 and 1 kg with a price increase of 100%. In view of these high transportation costs and high mark-up of the retailers, there seems a considerable potential to reduce the fertiliser price substantially.

Comments *by John Pender*

I am filling in as the discussant for Ruerd Ruben of Wageningen University, who could not be present. I am in a somewhat difficult position to review these three papers, as I am a co-author of one of the studies (the one by Holden, Shiferaw and Pender). In fact, Stein did virtually all of the work for that paper, though he was kind enough to include me as a co-author, so perhaps I can be objective. My comments will focus on the main findings and implications of the papers, rather than on the technical details. I will provide separate comments to the authors on the technical details where applicable.

The three papers presented represent a serious effort to understand the potentials and constraints to development in the sites studied, and I wish to commend the authors for this. In all cases the authors were able to draw upon detailed prior technical work that had already been conducted in the study areas by the Soil Conservation Research Programme in Andit Tid, Ethiopia (Holden et al.), by the International Livestock

4. In January 2002, US$ 1 = UGX 1738.70.

Research Institute in Holetta, Ethiopia (Ahmed et al.), and by the International Centre for Tropical Agriculture in Mayuge District, Uganda (Woelcke et al.). The authors have also conducted detailed socio-economic surveys upon which to base their understanding of the farming systems and to calibrate their models.

The conclusions reached by these papers are fairly sobering. In all cases, the studies were conducted in areas of medium to high agricultural potential, good market access and high population density. In the classification of development domains in the East African highlands, these study sites represent areas of relatively good prospects for sustainable development pathways. Yet, all of the models predict fairly limited impacts of most technology and policy scenarios considered on household incomes and, in the two papers that considered impacts on sustainability indicators (Holden et al. and Woelcke et al.), continued and worsening land degradation in most cases.

Some important general themes/lessons emerge from these papers. One is the primary importance of improving markets and identifying profitable opportunities if significant progress is to occur. As argued by Woelcke et al., soil nutrient depletion is likely to continue to be a major problem in Uganda unless the profitability of agriculture substantially improves. Adoption of inorganic fertilisers and other soil fertility-enhancing technologies is predicted by Woelcke et al. to be inadequate to halt declining fertility, unless there are major increases in output prices and/or major reduction in input prices. It is not clear whether the extent of improvement in price ratios considered by Woelcke et al. is feasible, though some information on marketing margins in Uganda were provided suggesting that significant improvement should be possible.

There appear to be some profitable development opportunities in the sites studied, even under current market conditions, though these are often outside of traditional food crop production. For example, Woelcke et al. predict that farmers' gross margins could be more than doubled by shifting to production of high-value horticultural crops. Holden et al. predict substantial increases in incomes as a result of off-farm and tree planting activities in northern Ethiopia. Surprisingly, Ahmed et al. do not consider potentials for livestock production, but I think that dairy development has significant potential to increase incomes in their study site (I expect they will address this issue in the next version of their paper). Thus, it is important to look beyond traditional food crop production to identify alternative development pathways.

A corollary of the primary importance of profitability is the limited impact of credit, unless it is linked to profitable opportunities. The Ahmed et al. paper demonstrates this well, predicting that if credit were provided in cash rather than in kind (as fertiliser), incomes would be little affected. The other papers also show fairly limited impact of credit by itself, compared to the impacts of off-farm employment opportunities, tree planting (Holden et al.) or shifts to higher value crops (Woelcke et al.).

A second lesson is that tradeoffs between goals of increasing incomes and ensuring sustainable use of resources are common. Various options using improved technologies and credit can improve incomes somewhat (all three papers), but land degradation is predicted to continue or worsen in many cases (Woelcke et al.; Holden et al.). In the paper by Woelcke et al., increased soil nutrient depletion results as new technologies enable greater crop yields, because some nutrients are not being adequately replenished

by the technologies adopted. Furthermore, if farmers shift to higher value horticultural crops, Woelcke et al. predict higher incomes but faster rates of depletion of some soil nutrients. In the paper by Holden et al., fertiliser and credit availability reduce farmers' incentive to invest in soil conservation, since fertiliser use enables farmers to maintain or increase yields without as much investment. Off-farm income opportunities are also predicted by Holden et al. to reduce soil conservation as a result of competition for labour.

There are not always trade-offs, however, particularly if different approaches can be combined in useful ways. Holden et al. find that tree planting on land unsuitable for crop production can substantially increase incomes with little impact on soil erosion, and that if this is combined with use of food-for-work programmes to promote soil conservation, erosion can be significantly reduced while incomes increase. Identifying such 'win-win' opportunities is an important objective. Nevertheless, such outcomes may not always be possible, and trade-offs will often need to be considered.

A few other important issues were raised by at least one of the three papers. The overriding importance of controlling population growth was implied in the paper by Holden et al. Without reducing the rate of population growth, people will continue to become poorer in the Ethiopian highlands, regardless of what is done with respect to promoting improved farming technologies, tree planting etc. There is little prospect for people to move out of poverty when they are surviving on only one or two hectares of land, which are usually degraded. In the long run, the solution will require reduced population growth and development in the non-farm economy, allowing labour to shift out of agriculture. But other strategies are still needed in the near to medium-term, since population is continuing to grow rapidly and opportunities in the non-farm economy are still limited, and largely linked to agricultural production.

Another important issue raised is the linkage between poverty and land degradation. Woelcke et al. find that poverty and consumption constraints contribute to farmers' lack of adoption of improved technologies (though profitability is the most important factor, as noted earlier). Holden et al. find that land constraints cause poor farmers to dismantle conservation structures if those reduce yields in the near term (by taking up space), even if they increase yields in the long term. Thus, poverty can contribute to land degradation and vice-versa, contributing to a downward spiral of land degradation–poverty–more land degradation. The linkage of poverty to land degradation is not automatic, however. Nevertheless, the larger need is to identify profitable activities for governments and households to invest in and ensure that markets and other institutions function well enough to enable those investments to occur, whether they be investments in natural, physical, human or social capital. Without such profitable investment opportunities, farmers in the East African highlands will inevitably be forced to deplete their stock of assets, including land resources as well as other assets.

This modelling work is valuable in helping to identify where such investment opportunities may be, and what constraints must be addressed to realise those opportunities. Although the story from these studies is not entirely positive, it is not hopeless either. By identifying where potential development pathways may lie and what

trade-offs and constraints must be addressed to attain them, these studies can provide useful input to policy makers.

Appendix I: Conference programme

Sustainable land management policies in the East African highlands: Regional policy conference

Objectives

1. To review, discuss and synthesise the findings and policy implications of research related to sustainable land management in the East African highlands regions
2. To increase policy makers and other stakeholders' awareness of the impacts of policies, programmes and other factors on land management, agricultural productivity, poverty and food security
3. To discuss promising strategies to promote more sustainable land management, increased agricultural productivity, and reduced poverty and food insecurity, and consider priorities for policy action and further research.

Venue

United Nations Economic Commission for Africa (UNECA)
Addis Ababa, Ethiopia
April 24–26, 2002

Co-sponsors

- International Food Policy Research Institute (IFPRI)
- International Livestock Research Institute (ILRI)
- East and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA)
- International Centre for Research in Agroforestry (ICRAF)
- African Highlands Initiative (AHI)
- Soil, Water and Nutrient Management Programme (SWNM)
- United Nations Economic Commission for Africa (UNECA)
- Regional Land Management Unit (RELMA)

Agenda

Wednesday, April 24

Session 1: Opening

Chairperson: *Dr Simeon Ehui*, Co-ordinator, Livestock Policy Analysis, ILRI

Rapporteurs: *Pamela Jagger* and *Elias Mulugeta*

09:00	Welcome remarks	*Josué Dione*, UNECA *Don Peden*, ILRI *John Pender*, IFPRI *Isaac Minde*, ECAPAPA *Frank Place*, ICRAF
09:30	Opening of conference	*Honourable Belay Ejigu*, Ministry of Agriculture, Ethiopia
09:45	Conference background, objectives and agenda	*Simeon Ehui*, ILRI
09:55	Questions/clarifications	
10:00	Research background, objectives, conceptual framework and activities	*John Pender*, IFPRI
10:20	Questions/clarifications	
10:30	Coffee/photograph	

Session 2: Development domains and strategies in the East African highlands

Chairperson: *Honourable Dr W. Kisamba-Mugerwa*, Minister of Agriculture, Uganda
Rapporteurs: *Zeleka Paulos* and *Abebe Misgina*

11:00	Development domains in East Africa and a strategic planning framework for land use	*Stan Wood*, IFPRI
11:20	Questions/clarifications	
11:30	Village stratification for policy analysis: multiple development domains in the Ethiopian highlands	*Gideon Kruseman*, WUR
11:50	Questions/clarifications	
12:00	Discussants' comments	*Samuel Benin*, ILRI
12:10	General discussion	
12:30	Lunch/press briefing	

Session 3: Development pathways and land management in the East African highlands

Chairperson: *Dr Tenkir Bonger*, Prime Minister's Office, Ethiopia
Rapporteurs: *Ayele Solomon* and *Amare Teklu*

14:00	Livelihood strategies and land management practices in the highlands of Tigray	*John Pender*, IFPRI

14:30	Questions/clarifications	
14:40	Land management policy in the Oromiya region	*Aliye Hussein*, Oromiya Agricultural Research Institute
15:00	Questions/clarifications	
15:10	Development pathways and land management in Uganda	*Ephraim Nkonya*, IFPRI
15:40	Questions/clarifications	
16:00	Coffee	
16:30	Development pathways in medium-high potential Kenya: A meso-level analysis of agricultural patterns and determinants	*Frank Place*, ICRAF
16:50	Questions/clarifications	
17:00	Discussants' comments	*Berhanu Gebremedhin*, ILRI *Frank Place*, ICRAF
17:20	General questions/discussion	
18:00	Close	
18:30	Reception	

Thursday, April 25

Session 4: Development pathways and land management: Case studies

Chairperson: *Honourable Grace Akello*, Minister of Gender, Labour and Social Development, Uganda
Rapporteurs: *Pamela Jagger* and *Elias Mulugeta*

09:00	Land degradation, investment, information and incentives in Kenya's Lake Victoria Basin	*Brent Swallow*, ICRAF
09:20	Questions/clarifications	
09:30	Agricultural land management by households in the highlands of Kenya	*Frank Place*, ICRAF
09:50	Questions/clarifications	
10:00	Land management problems and potentials in the lakeshore intensive banana–coffee farming system	*Dick Sserunkuuma*, Makerere University
10:20	Questions/clarifications	
10:30	Coffee	
10:50	Discussant's comments	*Isaac Minde*, ECAPAPA
11:00	General questions/discussion	

Session 5: Factors influencing land management – Ethiopia

Chairperson: *Dr Aberra Debelo*, Deputy Director General, EARO
Rapporteurs: *Zeleka Paulos* and *Abebe Misgina*

11:30	Policies affecting land management, input use and productivity: Land redistribution and tenure in the highlands of Amhara region	*Samuel Benin*, ILRI
11:50	Questions/clarifications	
12:00	Livestock, livelihood and land management issues in the highlands of Ethiopia	*Mohammad Jabbar*, ILRI
12:20	Questions/clarifications	
12:30	Lunch	
13:30	Community natural resource management in the highlands of Ethiopia	*Berhanu Gebremedhin*, ILRI
13:50	Questions/clarifications	
14:00	Sources of productivity differences in the Ethiopian highlands	*Simeon Ehui*, ILRI
14:20	Questions/clarifications	
14:30	Discussants' comments	*Stein Holden*, Agricultural University of Norway *Ephraim Nkonya*, IFPRI
14:50	General questions/discussion	

Session 6: Factors influencing land management – Uganda

Chairperson: *Mr Chebet Maikut,* President, Uganda National Farmers Federation
Rapporteurs: *Ayele Solomon* and *Amare Teklu*

15:30	The role of micro-credit in addressing land degradation in Uganda	*Honourable Grace Akello*, Ministry of Gender, Labour and Social Development, Uganda
15:50	Questions/clarifications	
16:00	Coffee	
16:20	Dynamics of maize market integration in post-liberalised Uganda	*Shahidur Rashid*, IFPRI
16:40	Questions/clarifications	
16:50	Motivating smallholder investment in sustainable land management: Emerging roles for NGOs and CBOs in Uganda	*Pamela Jagger*, IFPRI
17:10	Questions/clarifications	

17:20	Discussant's comments	*Dick Sserunkuuma*, Makerere University
17:30	General discussion	
18:00	Close	

Friday, April 26

Session 7: Factors influencing land management and food security – Other countries

Chairperson: *Dr Willis Oluoch-Kosura*, Head, Agricultural Economics Department, University of Nairobi
Rapporteurs: *Pamela Jagger* and *Elias Mulugeta*

09:00	Impact of land tenure on food security in Africa: An empirical study of selected African countries	*Josué Dione*, UNECA
09:20	Questions/clarifications	
09:30	Macro-economic and sectoral policies and their influence in land use and management: Some lessons from southern Africa	*Isaac Minde*, ECAPAPA
09:50	Questions/clarifications	
10:00	Discussant's comments	*Simeon Ehui*, ILRI
10:10	General discussion	

Session 8: Impacts of land management practices

Chairperson: *Mr Charles Gashumba*, Director, Agricultural Policy Secretariat, Uganda
Rapporteurs: *Zeleka Paulos* and *Abebe Misgina*

10:30	Integrated resource management for improving land productivity in the Ethiopian highlands	*Jens Aune*, NORAGRIC
10:50	Questions/clarifications	
11:00	Coffee	
11:30	Impacts of land management options in Western Kenya and eastern Uganda	*Rob Delve*, TSBF/CIAT
11:50	Questions/clarifications	
12:00	Soil organic matter and its relationship to soil fertility changes in Uganda	*Henry Ssali*, NARO
12:20	Questions/clarifications	

12:30	The potential benefit of velvet bean (*Mucuna pruriens*) and N-fertilisers in maize production on contrasting soils in Uganda	*C.K. Kaizzi*, NARO and University of Bonn
12:50	Questions/clarifications	
13:00	Lunch	
14:00	Discussants' comments	*Henry Ssali*, NARO *Jens Aune*, NORAGRIC
14:10	General questions/comments	

Session 9: Modelling impacts of alternative policies and technologies

Chairperson: *Dr John Lynam*, Rockefeller Foundation
Rapporteurs: *Ayele Solomon* and *Amare Teklu*

14:40	Policy analysis for sustainable land management and food security in the Ethiopian highlands: A bio-economic model with market imperfections	*Stein Holden*, Agricultural University of Norway
15:00	Questions/clarifications	
15:10	Modelling impacts of alternative policies in the highlands of Oromiya	*Mohamed Ahmed*, ILRI
15:30	Questions/clarifications	
15:40	Land improvement and technology diffusion in Uganda: A bio-economic multi-agent approach	*Thomas Berger*, University of Bonn
16:00	Questions/clarifications	
16:10	Coffee	
16:30	Discussant's comments	*John Pender*, IFPRI
16:40	General questions/comments	

Session 10: Conclusions and implications

Chairperson: *Honourable Ato Belay Ejigu*, Vice Minister of Agriculture, Ethiopia
Rapporteurs: *Pamela Jagger* and *Zeleka Paulos*

17:00	Discussion of lessons learned, policy implications, and future research needs	*John Pender*, IFPRI *Simeon Ehui*, ILRI
18:00	Closing of conference	

Appendix II: List of participants

Ethiopia

Amhara Region

Dereje Biruk
Head, ANRSBOA
P.O. Box 437, Bahir Dar
Tel.: +251–8 200929
Fax: +251–8 201510

Simachew Kassahun
Head, Planning and Agriculture Information
ANRSBOA
P.O. Box 437, Bahir Dar
Tel.: +251–8 205849
Fax: +251–8 201510
semachewk@yahoo.co.uk

Ayalew Gobezie
Head, ANRSBOFED
Bahir Dar
Tel.: +251–8 200215
Fax: +251–8 200444

Mulugeta Seid
Amhara Food Security Programme
Bahir Dar
Tel.: +251–8 200497

Oromiya Region

Yadessa Dinsa
Head, Land Use Planning Department
ONRDEPA
P.O. Box 8770, Addis Ababa
Tel.: +251–1 511698
research.oadb@telecom.net.et

Siraj Bekelie
Senior Expert, ONRDEPA
P.O. Box 8770, Addis Ababa
Tel.: +251–1 623589

Aliye Husen
Head, Oromiya Agric. Research Institute
P.O. Box 8770, Addis Ababa
Tel.: +251–9 20691
asoba a@yahoo.com

Abajobir Mohammednur Abachebsa
Head, ONRDEPA
P.O. Box 8770, Addis Ababa
Tel.: +251–1 510185 / 9 202157
research.oadb@telecom.net.et

Mesfin Nemera
Head, Oromiya Planning and Econ. Devt.
P.O. Box 32, Addis Ababa
Tel.: +251–1 155182
obped@telecom.net.et

Tigray Region

Dereje Assefa
Faculty of Dryland Agriculture
Mekelle University
P.O. Box 231, Mekelle
Tel.: +251–4 409015
derejeaa@yahoo.com

Yohannes Haile
Head, BOPED
Mekelle

Tesfay Hagos
Bureau of Agriculture
P.O. Box 10, Mekelle
Tel.: + 251–4 400005

EARO

Abera Debelo
Deputy Director General, EARO
P.O. Box 2003, Addis Ababa
Tel.: +251–1 460380
Fax: +251–1 461294
iar@telecom.net.et

Paulos Dubale
Director, Soil and Water Research Programme
P.O. Box 2003, Addis Ababa
Tel.: +251–1 454437
Fax: +251–1 461294
iar@telecom.net.et

Gezahegne Ayele
Agricultural Economist
EARO, Debre Zeit
Tel.: +251–338555
Fax: +251–338061
dzarc@telecom.net.et

Agajie Tesfaye
EARO
Holetta Research Centre
Holetta
Tel.: +251–370300

Yonas Yemshaw
FRC/EARO Ethiopia
P.O. Box 23838 Code 1000, Addis Ababa
Tel.: +251–1 456576/77 / 9 211543
Ntsp@telecom.net.et

ILRI

P.O. Box 5689
Addis Ababa
Tel.: +251–1 463215
Fax: +251–1 461252

Donald G. Peden
Director, Ethiopia
d.peden@cgiar.org

Simeon Ehui
Co-ordinator, LPAP
s.ehui@cgiar.org

Edward Rege
Animal Breeder
e.rege@cgiar.org

Pascal Bonnet
Animal Health Economist
p.bonnet@cgiar.org

Mohammad Jabbar
Agricultural Economist
m.jabbar@cgiar.org

Mohamed Ahmed
Agricultural Economist
m.ahmed@cgiar.org

Berhanu Gebremedhin
Post Doctoral Fellow
b.gebremedhin@cgiar.org

Samuel Benin
Agricultural Economist
s.benin@cgiar.org

Mamadou Diedhou
Head, Biometrics Unit
m.diedhou@cgiar.org

Salvador Fernandez
Co-ordinator, LFNP
s.fernandez@cgiar.org

Assegid W/Alemahu
Research Assistant
a.workalemahu@cgiar.org

Abebe Misgina
Research Assistant
a.misgina@cgiar.org

Elias Mulugeta
Research Assistant
e.mulugeta@cgiar.org

Martha Negash
Consultant
m.negash@cgiar.org

Ayele Solomon
Research Assistant
a.solomon@cgiar.org

Amare Teklu
Consultant
a.teklu@cgiar.org

Zelekawork Paulos
Research Assistant
z.paulos@cgiar.org

Yemesserach Assefa
Consultant
y.assefa@cgiar.org

Solomon Tesfay[*]
Research Assistant

Mattthieu Lesnoff
Scientific Researcher
m.lesnoff@cgiar.org

Muluhiwot Getachew
Programme Administrative Officer
m.getachew@cgiar.org

Selamawit Dominique
Secretary
s.dominique@cgiar.org

United Nations Offices

UNECA
P.O. Box 3005
Addis Ababa
Tel.: +251–1 517200
Fax: +251–1 514416

Maurice Tankou
Agricultural Expert
mtankou@uneca.org

Awere Kwame
akwame@uneca.org

Joan Kagwanja
Agricultural Economist
jkagwanja@uneca.org

Chol O. Han
Population Expert
chan@uneca.org

Isatou Gaye
Environment Expert, FSSDD
Igaye@uneca.org

* Solomon Tesfay passed away during the write up of this Working Paper.

Other UN Offices

Theodros Eshetu
UNEP, Addis Ababa
Tel.: +251–1 558155

Pierre-Louis Raoul
UNICEF, Addis Ababa
Tel.: +251–9 208903

Olivia Achu Mbatang
C/o Samuel Nyambi
UNDP, Addis Ababa
Tel.: 251–1 511025
Fax: 251–1 515177

George K. Mburathi
FAO Representative in Ethiopia OAU
and ECA/FAO
P.O. Box 5536
Addis Ababa
Tel.: +251–1 153487
Fax: +251–1 515266

Sintayehu Gebremariam
National Programme Officer
FAO
P.O. Box 5536, Addis Ababa
Tel.: +251–1 511394

Universities and government organisations

Mulat Demeke
Dean, Faculty of Business and Economics
Addis Ababa University
P.O. Box 5563, Addis Ababa
Tel.: +251–1 562370
Fax: +251–1 552227
fbe.aau@telecom.net.et

Tassewe W/Hanna
Assistant Professor
Addis Ababa University
P.O. Box 5563, Addis Ababa

Tesfaye Teklu
Department of Economics
Addis Ababa University
P.O. Box 5563, Addis Ababa
Tel.: +251–1 159935

Workneh Negatu
Director, IDR
Addis Ababa University
P.O. Box 5563, Addis Ababa

Belay Kassa
Associate Professor
Alemaya University
P.O. Box 138, Dire Dawa
Tel.: +251–5 112374
belayk@hotmail.com

Belay Ejigu
Vice Minister, Ministry of Agriculture
P.O. Box 62347, Addis Ababa
Tel.: +251–1 522276
Fax: +251–1 512984
moavm@telecom.net.et

Newai GebereAb
Minister
Economic Advisory to the Prime Minister
P.O. Box 2479, Addis Ababa
Tel: +251–1 552244
Fax: +251–1 569084

Tenkir Bonger
Chief Expert of Agriculture
Ethiopian Development and Research Institute, Addis Ababa
Tel.: +251–1 562654
Fax: +251–1 553489
edri@telecom.net.et

Zeleke Desalegn
General Manager
National Fertiliser Industry Agency
P.O. Box 101473, Addis Ababa
Tel: +251–1 209994/519061

Belay Demissie
Team Leader
Seed Industry Agency
Box 102251, Addis Ababa
Tel.: +251–1 186006
Fax: +251–1 519051

Joseph Mburu
Co-ordinator
National Soil and Water Conservation Programme

Peter J. Sutcliffe
Team Leader, Woody Biomass
P.O. Box 26798, Addis Ababa
Tel.: +251–1 615302
Fax: +251–1 46115
wgbispp@telecom.net.et

Non-governmental organisations

Tehout Yirgu
CARE Ethiopia
P.O. Box 4710, Addis Ababa
Tel.: +251–1 463422
Fax: +251–1 461969

Gaesing Karin
GTZ
P.O. Box 12631, Addis Ababa
Tel.: +251–1 515014
Fax: +251–1 513572

Gunther Haase
GTZ
P.O. Box 12631, Addis Ababa
Tel.: +251–1 56009
Fax: +251–1 519977

Akalework Bantirgu
CRDA
Addis Ababa

Takele Gebre
Programme Co-ordinator
Sasakawa Global 2000
P.O. Box 12771, Addis Ababa
sg2000@telecom.net.et

Embassies and donor agencies

Erik Korsgren
Counsellor, Swedish Embassy
Addis Ababa
Tel.: +251–1 515830
erikkorsgren@sida.se

Tadele G/Selassie
Food Security Manager
USAID
P.O. Box 1014, Addis Ababa
Tel.: +251–1 510088
Fax: +251–1 510043

Mauro Ghirotti
Director
Italian Development Co-operation Office
P.O. Box 1105, Addis Ababa
Tel.: +251–1 552264
Fax: +251–1 552807

Other organisations and individuals

Akalewold Bantirgu
P.O. Box 5674, Addis Ababa
Tel.: +251–1 650100
Fax: +251–1 667206

Menbere W/Giorgis
Photographer

Germany

Almut Brunner
Centre for Development Research
Maxstrasse 10 53111, Bonn
Tel.: 0228–9650994
abrunner@giub.uni-bonn.de

Thomas Berger
Professor
University of Bonn
Tel.: 228 734964
t.berger@uni-bonn.de

Johannes Woelcke
PhD student
University of Bonn
Tel.: 0049 228731728
j.woelcke et al.@uni-bonn.de

Assefa Admassie
University of Bonn
Walter Flex Street 3
53113 Bonn
Tel.: 49 228 731716
Fax: 49 228 731869/1849

C.K. Kaizzi
PhD student
University of Bonn

Japan

Keijro Otsuka
Director, FASID
Tokyo
Otsuka@grips.ac.jp

Hiroshi Tsujii
Kyoto University
Tel: 81–757536292
tsujii@kais.kyoto-u.ac.jp

Kenya

Wilson Wasike
Policy Analyst, KIPPRA
P.O. Box 56445, Nairobi
Tel.: 254–2 719933/34
Fax: 254–2 719951
wwasike@kippra.or.ke

Eugene Muramira
Director, National Environmental
Management Authority
Nairobi

Willis Oluoch-Kosura
Chair, Departement of Agricultural Economics
University of Nairobi
P.O. Box 24053, Nairobi
Tel.: 254–2 631340

John Lynam
Rockefeller Foundation
P.O. Box 47543, Nairobi
Tel.: 254–2 228061

Frank Place
Economist, ICRAF
P.O. Box 30677, Nairobi
Tel.: 254–2 524000
Fax: 254–2 524001
f.place@cgiar.org

Brent Swallow
Programme Leader, ICRAF
P.O. Box 30677, Nairobi
Tel.: 254–2 524000
Fax: 254–2 524001

Joshua Ramisch
Tropical Soil Biology and Fertility Institute (CIAT)
P.O. Box 30592, Nairobi
Tel.: 733 788 314

Hayden Louise
C/o TSBF UNESCO
P.O. Box 30592, Nairobi

Grunder Martin
Caritas Internationalis
P.O. Box 14954, Nairobi
Tel.: 254–2 447699/448571

Kangethe Gitu
Researcher, Lecturer
University of Nairobi
P.O. Box 49038, Nairobi
Tel: 0154 31492

Erica Marie
C/o TSBF-UNESCO
Box 30592, Nairobi
Tel.: 254 841 28

Anthony Muchanga
Central Bureau of Statistics
Government of Kenya
P.O. Box 30266, Nairobi
Tel.: 254–2 333971
asmuchanga@hotmail.com

Bekele Tessema Azene
Adviser, RELMA
Box 63403, Nairobi
Tel: 254–2 524412
Azene.Bekele@cgiar.org

The Netherlands

Girmay Tesfaye
Wageningen University
Hollandseweg 1, 6704 KN
Tel.: 317 319540

Gideon Kruseman
Development Economics Group
Wageningen University
Hollandseweg 1, 6704 KN
Tel.: 31 31748255
Fax: 31 31748404
gideon.kruseman@alg.oe.wag-ur.nl

Norway

Stein Holden
Associate Professor
Agricultural University of Norway
Tel.: 64948603/8655
stein.holden@ios.nlh.no

Jens Aune
Researcher
NORAGRIC
P.O. Box 5001
Tel.: 64–94 07 60
jens.aune@noragric.nlh.no

Uganda

Isaac J. Minde
Co-ordinator, ASARECA/ECAPAPA
P.O. Box 765, Entebbe
Tel.: 41–32178
ecapapa@imul.com

W. Kisamba-Mugerwa
Minister of Agriculture, Animal Industry and Fisheries
P.O. Box 102251, Kampala
Tel.: 320752

Grace Akello
Minister Gender, Labour and Social Development, Kampala

Ephraim Nkonya
Post Doctoral Research Fellow
IFPRI Uganda
P.O. Box 28565, Kampala
Tel.: 41–234613
enkonya@cgiar.org

Pascal Sanginga
Co-ordinator, Kabale Benchmark Site
CIAT Kawanda Research Institute
Entebbe
Tel.: 41–56767
Fax: 41–567635
sanginga@infocom.co.ug

Dick Sserunkuuma
Agricultural Economist/Lecturer
Makerere University
P.O. Box 7062, Kampala
Tel.: 77–504454

Julius Y.K. Zake
Chairman, Soil Fertility Initiative
Makerere University
P.O. Box 7062, Kampala
Tel.: 540707

Henry Ssali
Head, Soil and Soils Fertility Management
Kawanda Agricultural Research Institute
P.O. Box 7065, Kampala
Tel.: 567696
landuse@infocom.co.ug

Charles H. Gashumba
Director, Ministry of Finance
P.O. Box 10870, Kampala
Tel.: 233819
Fax: 344322

Chebet Maitkut
Director
Uganda National Farmers Association
P.O. Box 16014, Kampala
Tel.: 77–409414
Fax: 41–531638
unfa@starcom.co.ug

Rhoda P. Tumisiime
Commissioner of Planning
Directorate of Planning
IFPRI/Uganda
P.O. Box 102251
Tel.: 41.320722
Fax: 41.320069
rhoda@infocom.co.ug

Robert Delve
TSBF-CIAT
P.O. Box 6247, Kampala
Tel.: 41 56767

Christopher G. Kiwanuka
P.O. Box 352
Tel.: 041–230 218 075/696239
Fax: 041 251949

Yakobo Moyini
Interim Chairman
Environmental Economic Association of Uganda
eeau@africaonline.co.ug

Augus Jonah Bwiragura
Chief Government Valuer
IFPRI, Uganda
P.O. Box 7061
Tel.: 041 233337

Simon Bolwig
Research Analyst
IFPRI, Uganda
P.O. Box 28565
Kampala
Tel: 41–234 616

USA

IFPRI

2033 K Street NW
Washington, DC 20006, USA
Tel.: +1 202 8625
Fax: +1 202 4674 439

John Pender
Senior Research Fellow
j.pender@cgiar.org

Pamela Jagger
Research Analyst
p.jagger@cgiar.org

Stanley Wood
Senior Scientist
s.wood@cgiar.org

Shahidur Rashid
Post Doctoral Fellow
s.rashid@cgiar.org

Michelle Pietrowski
Communications Specialist
m.pietrowski@cgiar.org

Other USA organisations and individuals

Gilles Bergeron
Sociologist
USA/FANTA-AED
FANTA 1875 Connecticut Ave.
Washington, DC 20009, USA
Tel.: +1 202 884 8 941
gbergero@smtp.aed.org

Peter D. Little
Departement of Anthropology
University of Kentucky
Tel.: +1 859 257 6923
Fax: +1 859 323 1959
pdlitt1@pop.uky.edu

Sisay Assefa
Professor
Western Michigan University
Kalama 200, MI 49009